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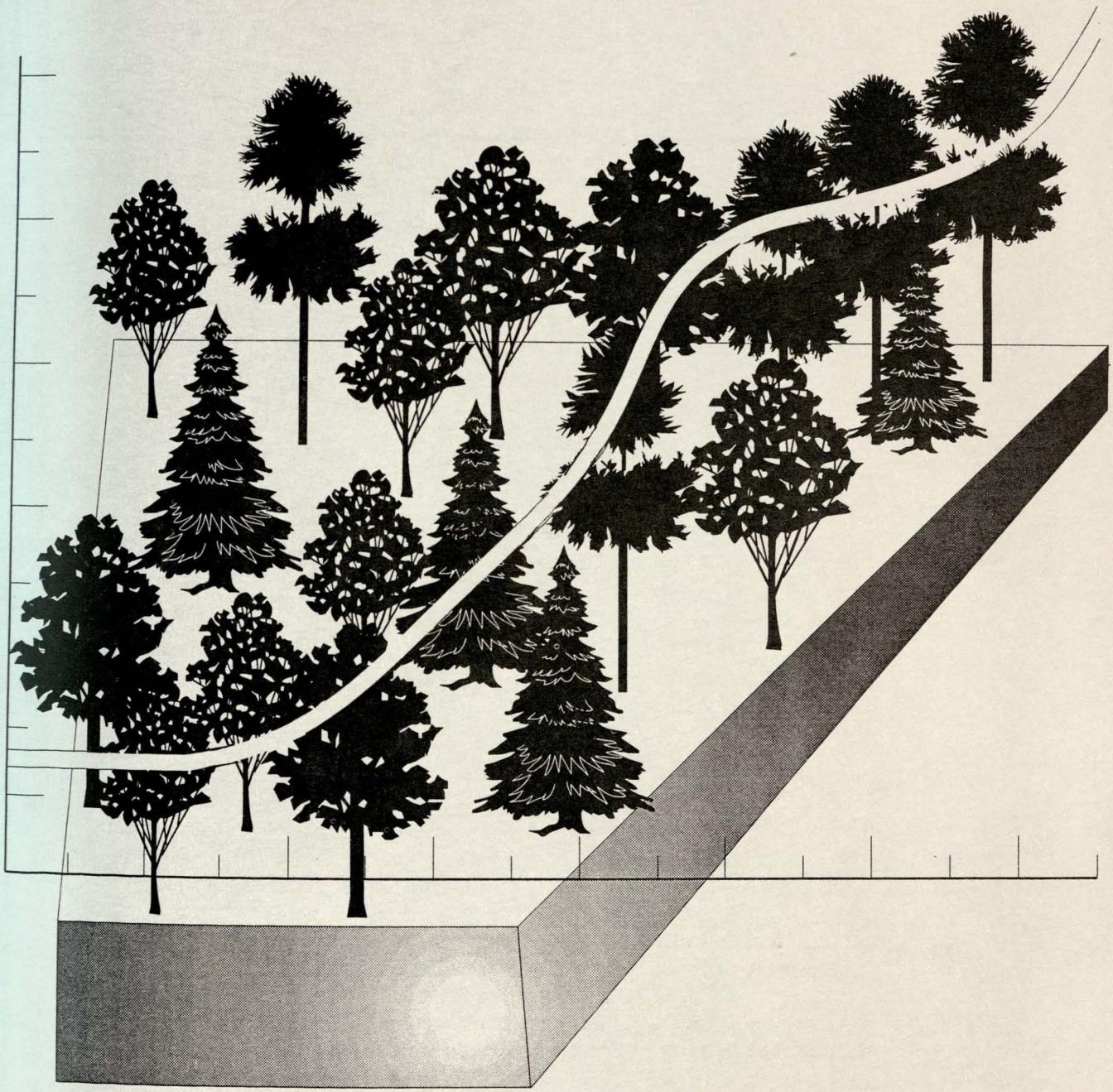
The Forest Resources of the Ottawa National Forest, 1993

Earl C. Leatherberry and James L. Meunier



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This report includes the most commonly used U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis (FIA) statistics. Additional forest resource data can be provided. Persons requesting additional information from the raw inventory data are expected to pay the retrieval costs. These costs range from less than $100 for a relatively simple request to more than $2,000 for a complex retrieval involving the services of a Forest Inventory and Analysis computer programmer. Requests will be filled so as to minimize the impact on the Forest Inventory and Analysis staff. FIA data are also available on CD-ROM from the North Central Station, and on the INTERNET at http://www.ncfes.umn.edu/units/4801.

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The Forest Resources of the Ottawa National Forest, 1993

Earl C. Leatherberry and James L. Meunier

The Ottawa National Forest is located at the western end of Michigan's Upper Peninsula (fig. 1). The Forest was named for Indian people who once lived in Michigan. It dates back to 1928, when the National Forest Reservation Commission designated portions of Houghton, Baraga, Iron, Ontonagon, and Gogebic Counties as the Ottawa Purchase Unit. In 1931, the purchase unit was formally designated the Ottawa National Forest by President Hoover. Since 1931, a number of acquisitions have been made to bring the Forest to its present size.

The topography of the Ottawa National Forest ranges from sand plains on the east to the rugged hills of the Keweenaw Highland in the northwest. Soils are mostly of glacial origin and range from pure sand to clay. Peat and muck are found in depressions formerly occupied by water. In the southern portion of the Forest, there are numerous lakes; in the north, many streams flow into Lake Superior through deep, narrow valleys. The climate is characterized by mild summers and by cold winters with deep snow and temperatures frequently below zero. The topography and climate of the area combine to support an association of flora and fauna forming an ecological landscape that is diverse and in many ways unique. For example, within the Ottawa, there are 2,000 miles of streams where waterfalls are common and more than 700 lakes. Those waters provide habitat for a variety of fish species, including walleye; northern pike; brook, rainbow, brown, and lake trout; and panfish. The adjacent riparian areas support reptiles and amphibians as well as flora that include rare orchids. The forested areas provide habitat for larger mammals such as black bear (*Ursus americanus*) and white-tailed deer (*Odocoileus virginianus*). The Ottawa National Forest, which includes the McCormick, Sylvania, and Sturgeon River Gorge National Wilderness Areas, provides habitat for moose *(Alces alces)*, gray wolves *(Canis lupus)*, and bald eagles *(Haliaeetus leucocephalus)*—all once thought to be nearly extinct in the area. Magnificent stands of white pine, hemlock, and hardwoods present images of an ancient forest within the three wilderness areas. The ancient volcanic rock of the Keweenaw Highland provides rugged terrain that is uncommon in the Upper Midwest.

In 1990, about 83,500 people maintained their residences in the five counties in which the Ottawa is located. Many of the area's residents rely on the resources of the Ottawa National Forest, and the area's forestry-related industries, for employment. A large portion of the area's economy is based on forestry and forest recreation. Most of the area's residents regard the forest affectionately and cherish the "north woods" lifestyle that it helps to support.

The relatively small local population and the area's land and water resources make the Ottawa attractive to outdoor recreationists. The Forest is relatively close to the major population centers and markets of the Upper Midwest; Chicago, Milwaukee, and Minneapolis/St. Paul are within about a half day's drive. During the summer, tourists and seasonal

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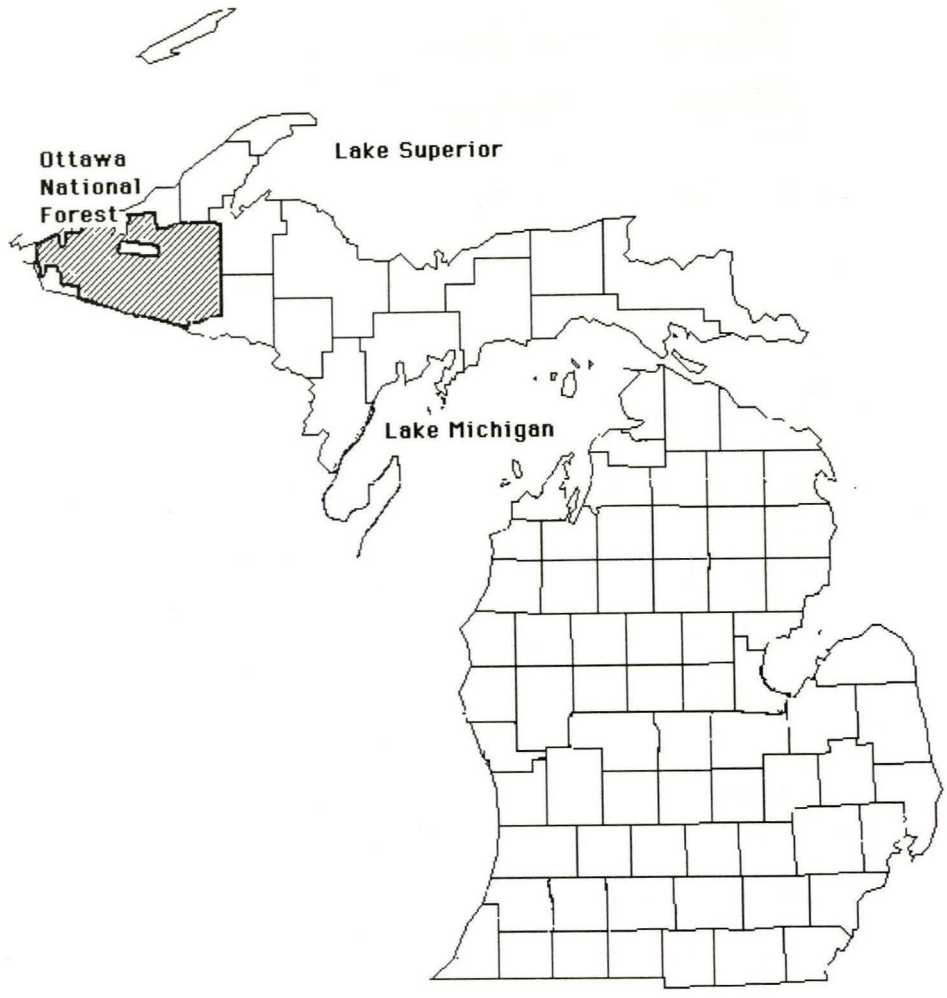

Figure 1.—*Location of the Ottawa National Forest.*

home owners temporarily increase the area's population. During the winter, especially on weekends, winter sport enthusiasts come to use the area's snowmobile and cross country ski trails and downhill ski areas. The Forest's proximity to the Midwest consumer market, a good highway network, and an ample water supply give the region's forest products industries a competitive advantage, particularly over the forest products industries in the South and Pacific Northwest.

For over 65 years, the Ottawa has successfully provided goods (primarily timber) and services (mostly recreational opportunities) to the public. To continue to provide these sometimes competing outputs while maintaining the ecological integrity of the Forest, managers have instituted a strategy that seeks to ensure the long-term sustainability of ecosystems that make up the Ottawa.

This report provides information about the status and condition of the timberland resources of the Ottawa National Forest. Data for this analysis were collected as part of the 1993 Michigan Forest Inventory conducted by the North Central Forest Experiment Station's Forest Inventory and Analysis (FIA) Unit. Data from other sources are used to provide historical information about the resources of the Ottawa. The primary focus of the analysis is detecting change in the status and condition of timber resources as determined from FIA data collected in 1980 and 1993, the two most recent FIA inventories for which data are available.

THE OTTAWA NATIONAL FOREST IN A HISTORICAL CONTEXT

The original forest in the area that is now the Ottawa National Forest was a mixture of hardwoods, spruce-fir, and swamp conifers, with scattered pockets of pines. The hardwood forest was composed mostly of a mixture of hard maple, hemlock, yellow birch, elm, and basswood trees. The spruce-fir forest was a mix of hardwoods and softwoods in which balsam fir, white spruce, northern white-cedar, soft maple, paper birch, and aspen trees were most prominent. Most of the pine forest was on sandy areas east of Lake Gogebic. White pine, red pine, and jack pine were present; white pine prevailed on the better soils, jack pine on the poorest. Swamp conifers—stands of black spruce, tamarack, and northern white-cedar—were found in marsh or swampy areas (Cunningham and White 1941).

As the region was opened to settlement, forest areas became more accessible and were open to logging. As early as 1844, a sawmill was operating near L' Anse, Michigan (Karamanski 1989). For the next 50 years, the pine resource, especially white pine, was intensively logged. Later, cedar, hemlock, and hardwoods became important (Karamanski 1989). By the 1920's, much of the forest land, especially where pine was found, had been logged, burned, and abandoned. From those devastated lands, the Ottawa National Forest was created. By the 1930's, the region's forest had rebounded and was an important source of pulpwood for paper manufacturing. In 1934, in the counties where the Ottawa is located, there were 68 sawmills operating. Sixteen of those sawmills each were cutting 1 million board feet or more annually (Cunningham and White 1941).

The period of extensive logging (1880-1920) changed the composition of the forest. On the land that became the Ottawa National Forest, much of the pine resource had been depleted, and the high quality hardwoods had been removed. In their place, aspen, jack pine, and second-growth hardwood stands appeared. Aspen and jack pine emerged largely as a result of fire. It is estimated that following the "logging era," 23 percent of the Ottawa's land had been burned over three to four times (Karamanski 1989). Because of fire, the most dramatic shift in species composition was the increase in the aspen-birch forest type. The second-growth hardwood stands appeared from seedlings (maples) and sprouting (elms, basswood, and red maple). However, some areas escaped the logger's saws. One place was the Sylvania Tract (now Sylvania Wilderness) in Gogebic County. There, towering red and white pines as well as the virgin northern hardwood forest was protected by their owners from cutting.

In the middle of the 20th century, the Ottawa was mostly a mix of second-growth northern hardwood and aspen-birch stands. Between 1949 and 1962, the proportion of the Ottawa where northern hardwood and aspen-birch types occurred increased, while area in pine and other conifers decreased (fig. 2). Between 1949 and 1962, the area in pine decreased from 69,200 acres to 57,000 acres (USDA Forest Service 1963). The change in area of pine was largely due to an increase of hardwood species in pine stands. The change to hardwood stands probably occurred because of slight changes in the mix of species. During the 1950's, trees on the Ottawa were growing larger in size. Poletimber stands increased by 183 thousand acres and occupied 57 percent of the Forest's timberland area (USDA Forest Service 1963). The increase in poletimber area occurred mostly in the northern hardwood and aspen-birch types. In 1949, only 34 percent of the total area of northern hardwood and aspen was in poletimber stands. In 1962, 57 percent of the area of these two types was in poletimber stands (USDA Forest Service 1963).

EXTENT OF FOREST LAND AND FOREST TYPES CHANGE, 1980-1993

The 1993 Michigan Forest Inventory revealed that the Ottawa National Forest contained an estimated 957,000 acres of land, of which 95 percent (908,600 acres) was forested. The 5 percent (48,400 acres) of land that was not forested was mostly wetlands, such as marsh and bogs, or land used as roads and utility rights-of-way.

Forest Inventory and Analysis (FIA) classifies forest land as either timberland, reserved timberland, or other forest land[1]. These and other standard FIA definitions were established so that forest information collected by the different FIA units could be compared, and

[1] *See Definition of Terms in the Appendix for definition of this and other terms used in the report.*

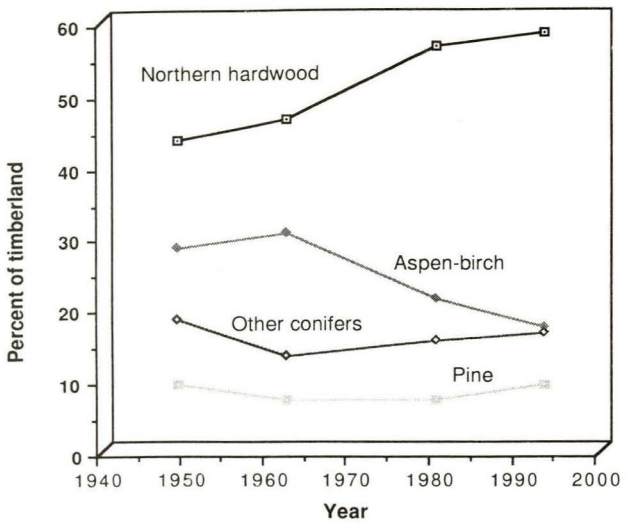

Figure 2.—*Estimates of change in forest areas between 1949 and 1993 by major forest types, Ottawa National Forest. (Note: Data for the first two points—1949 and 1962—were derived from estimates from the Ottawa National Forest Timber Management Plan-1963 through 1973, (USDA Forest Service 1963), and the last two—1980 and 1993—were derived from FIA inventories. Because of the combining of types, and different data sources points on the draft are not absolute, but merely estimates.)*

over time, trends could be identified. In a few instances, FIA definitions differ from terms used in the Ottawa's management plans and other Forest documents. This is especially true with land-use information. Therefore, the reader is cautioned that information presented here should not be compared with information in the Ottawa Land and Resource Management Plan or other Forest documents without accounting for differences in definitions and other considerations such as inventory methods. For example, the timberland classification implies that the land is capable of producing a sustained crop of wood and is not withdrawn from timber harvesting. However, this is not meant to imply that all timberland on the Ottawa is subject to harvest. The Ottawa's Land and Resource Management Plan details the allocation of land for specific land uses and management activities.

Using FIA definitions, virtually all (858,400 acres) the forest land on the Ottawa was classed as timberland as of the 1993 inventory. Most of the remaining forest land (49,300 acres) was classed as reserved timberland and is in the McCormick, Sturgeon River Gorge, and Sylvania National Wilderness Areas. Only an estimated 900 acres were classed as other forest land. Between the 1980 and 1993 inventories, timberland area on the Forest increased by an estimated 35,300 acres due to land exchanges and purchases.

In 1993, the maple-beech-birch forest type was the dominant forest type on the Ottawa, occupying more than half of the Forest's timberland (fig. 3). The second most abundant type was aspen. No other single forest type covered more than 10 percent of the Forest's timberland. As a group, hardwood forest types occupied three-fourths of the timberland.

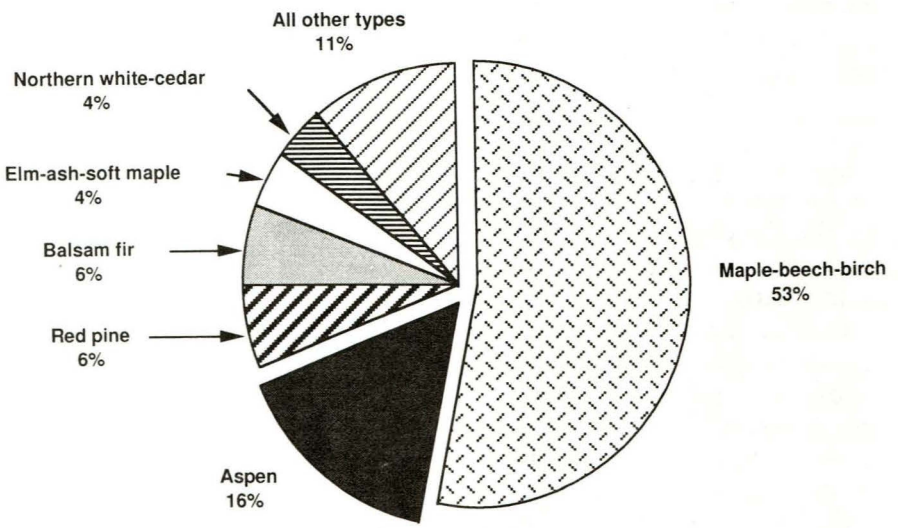

Figure 3.—*Area of timberland by major forest type, Ottawa National Forest, 1993.*

Between 1980 and 1993, some forest types expanded in area while others declined (fig. 4). Area in the maple-beech-birch forest type increased by an estimated 23,200 acres between inventories, the balsam fir type increased by 19,600 acres; and red pine type increased by about 15,000 acres. The expansion of other types was relatively small in terms of total acres. Among the major forest types, the most significant decline between inventories was in the aspen forest type—35,200 acres. The decrease in aspen acres continued a trend that started in the 1960's (see figure 2). The area of northern white-cedar and black spruce also declined. The decline in area of northern white-cedar and black spruce types is explained, and offset to some degree, by the increase in balsam fir and tamarack, both faster growing species that also grow in lowland, organic soils. Those species increased in dominance over black spruce and northern white-cedar.

TREE SPECIES COMPOSITION

One way to assess tree species diversity within FIA-designated forest types is to look at the net volume of wood contained in tree species within a particular type (see table 7). On the Ottawa, the jack pine forest type had the fewest associated species in 1993. Jack pine makes up 87 percent of the volume in the type, and the primary associated species were aspen, red pine, and paper birch. The other types on the Forest contain much more species diversity, particularly the maple-beech-birch type and the aspen type. In the maple-beech-birch type, hard maple was 42 percent of the net volume, followed by soft maple with 15 percent, yellow birch and hemlock each with 8 percent, and basswood with 7 percent of net volume. The remaining 20 percent of the volume in the maple-beech-birch type was a mixture of other species, with significant amounts of aspen, ash, cherry, northern white-cedar, balsam fir, and white spruce.

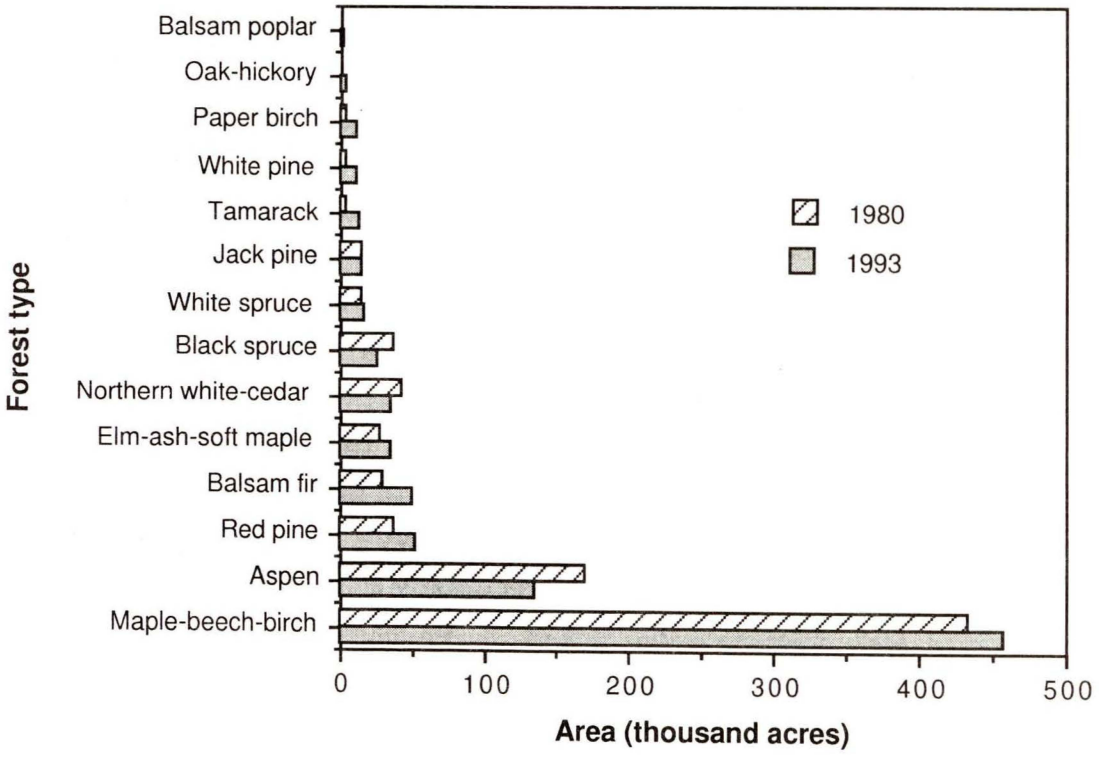

Figure 4.—*Area of timberland by forest type on the Ottawa National Forest, 1980 and 1993.*

Within the aspen type, the combined volume of bigtooth aspen, quaking aspen, and balsam poplar made up 51 percent of the net volume with the type. Other major species were balsam fir (8 percent), red maple (8 percent), white spruce (7 percent), white pine (5 percent), and paper birch (4 percent). Several other species occurred with smaller percent of volume.

The balsam fir type also contained a wide array of tree species. Balsam fir accounted for about 21 percent of the net volume in the type. Significant amounts of white spruce, white pine, and northern white-cedar occurred in the type. In addition, more than 36 percent of the volume was in hardwood species, and aspen, red maple, and paper birch were the most common.

RECENT CHANGE IN COMPOSITION OF TIMBERLAND

In 1993, there were an estimated 612.8 million trees at least 1 inch d.b.h., including cull trees, on the Forest. The most abundant tree species was hard maples, mostly sugar maple, with almost 145.7 million trees, accounting for about one-fourth of all trees on the Forest (fig. 5). There were nearly 100,000 quaking aspen trees. The other dominant tree species on the Ottawa were balsam fir and soft maples.

Between inventories, the Ottawa experienced a modest 3-percent increase in number of all live trees. However, there were significant shifts in species composition over the 13 years between inventories. An important shift involved aspen trees, which moved from being the fourth most common species in 1980, to the second most common in 1993. The number of quaking aspen trees increased by 109 percent, going from 47.6 to 99.5 million trees. The vast majority (88 percent) of quaking aspen trees in 1993 were seedling and sapling size (1 to 4.9 inches d.b.h.), which explains the increase in the numbers of aspen trees with a corresponding decrease in the aspen forest type. Paper birch, often found growing with aspen, increased in number by 28 percent. It is important to note that high rates of mortality from natural thinning occur in these young sapling stands as they mature.

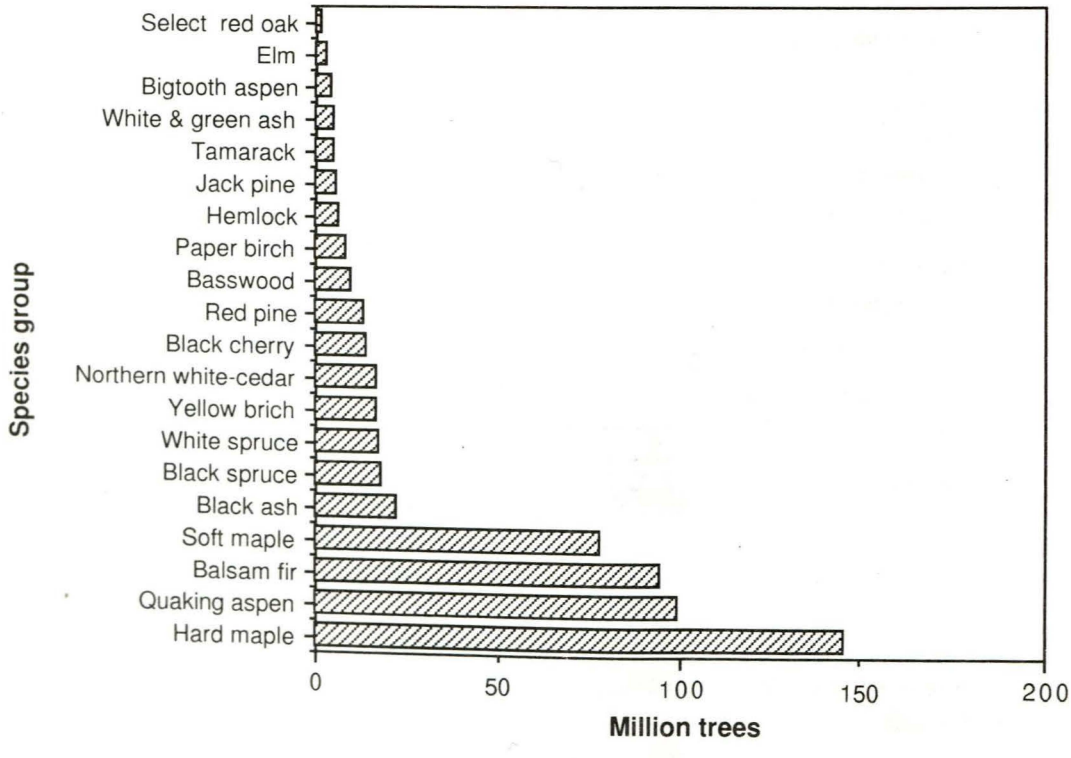

Figure 5.—*Number of all live trees by species group on timberland on the Ottawa National Forest, 1993.*

Between inventories, the number of soft maple trees increased by 4 percent, while the number of hard maples declined by 11 percent and the number of balsam fir trees declined by 10 percent. Black spruce and black ash trees shifted in order of ranking with the number of black spruce trees declining by 42 percent and the number of black ash trees increasing by 14 percent. The number of elm trees declined precipitously between inventories. In 1980, elm accounted for 2 percent of the Forest's trees. In 1993, it accounted for less than a half percent of the trees. Dutch elm disease eliminated most of the larger elm trees, but seedlings and saplings remain relatively abundant. In 1993, elm seedling and sapling trees accounted for 95 percent of the elm trees.

The relative presence of tree species can serve as an indicator of species composition over an area. However, because the life history of tree species varies, simply ascertaining the number of trees on the Forest may provide an incomplete or skewed view of relative species composition. Obviously, tree size is an important factor in viewing species composition over a given area. In the tabulation below, tree species are grouped to compare the relative abundance of tree species by two size groupings:

Tree species	Percent of total number of trees 1 inch d.b.h and larger	Percent of total number of trees 5 inches d.b.h. and larger
Hard maple	24	26
Soft maple	13	15
Balsam fir	15	8
Aspens	17	8
Northern white-cedar	3	6
Yellow birch	3	4
Red pine	2	5
Hemlock	1	2
Basswood	2	4
All other species	20	22
Total	100	100

The tabulation above illustrates a consistent relative abundance of hard and soft maples regardless of tree size. On the other hand, balsam fir and aspens are relatively less abundant when tree size is considered. Those species are especially skewed toward more small trees rather than large mature ones. Other species—northern white-cedar, yellow birch, basswood, hemlock, and red pine have a more significant presence than total trees over 1 inch d.b.h. would indicate.

RECENT CHANGE IN SIZE AND AGE STRUCTURE OF TIMBERLAND STANDS

The structure of stands changed rather dramatically between inventories (fig. 6). In 1980, 14 percent (111,200 acres) of the timberland area was in sapling-seedling-size stands, about 43 percent was in poletimber (354,200 acres), and another 43 percent was in sawtimber (353,300 acres)-size stands. In 1993, 23 percent (195,400 acres) of the timberland area was in sapling-seedling stands, 29 percent (251,900 acres) was in poletimber stands, and 48 percent (411,100 acres) was in sawtimber-size stands. Between inventories, the area in sapling-seedling and sawtimber stands increased, while the area in poletimber-size stands decreased. The change in stand-size classes between inventories suggests that the structure of stands is moving toward a more mature, uneven-aged structure. For example, the area in the jack pine type remained constant between inventories at 14,500 acres; however, the area in jack pine sawtimber stands increased from 3,700 to 6,200 acres. Also, red pine sawtimber stands increased in area from 6,900 acres in 1980, to 26,800 acres in 1993.

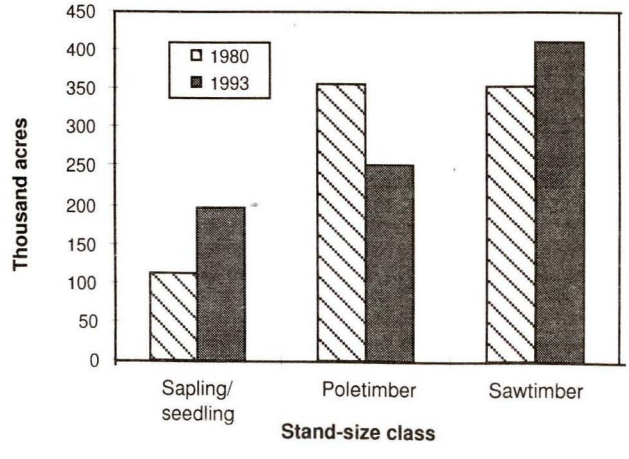

Figure 6.—*Area of timberland by stand-size class, Ottawa National Forest, 1980-1993.*

Although the area of sawtimber stands increased between inventories, the forest is still predominantly second-growth forests, with more stands breaking into the sawtimber-size class. Some of those stands have evolved to contain fairly large diameter trees. For example, in 1980 there were 1,017,000 trees 21 inches d.b.h. and larger on the Forest, an average of about 1.2 trees per acre in the class. In 1993, the total number of trees over 21 inches in diameter increased to 1,278,000 trees, an average of about 1.5 trees per acre in the class—a 20-percent increase per acre (see table 5 in Appendix).

Because stand growth is dynamic and many stands are maturing, the number of trees by diameter class is increasing on the Forest. For example, when all live trees at least 1 inch d.b.h. were grouped into 4-inch diameter classes, the number of trees in the 1- to 4.9-inch class increased slightly while trees in the 5- to 8.9-inch class declined; however, the number of trees in all other diameter classes increased (Table A). The average number of trees per acre over 17 inches d.b.h. increased from 4.7 to 5.9, a 26-percent increase between inventories. It is likely that the trend of larger trees will continue.

In 1993, the median age of timberland stands on the Ottawa was 60 years. Stands on the Ottawa can be grouped into four broad age categories: young stands—1 to 30 years old (20 percent of area); intermediate stands—31 to 60 years old (30 percent of area); mature stands—61 to 100 years old (35 percent of area); and old stands—more than 100 years old (15 percent of area). Between inventories, there were changes in the age structure, with stands generally getting older. Area in older stands (older than 100 years) increased by 67 percent (50,000 acres). Of the four age categories, the intermediate age category was the only group to experience a decrease in area, a rather substantial one—between inventories. Stands in the intermediate age category decreased by 23 percent (78,000 acres). The changes in age class structure are consistent with the upward trend in diameter classes.

Stand age varied by forest type. Old forest stands were primarily in the maple-beech-birch type. Sixty-nine percent of the area in stands older than 100 years were in the maple-beech-birch type. The young stands were predominately aspen. Nearly half of the area in young stands was in the aspen forest type.

RECENT CHANGE IN TIMBER VOLUME

Between 1980 and 1993, net growing-stock volume increased 7 percent—from nearly 1.2 billion cubic feet to 1.3 billion cubic feet. The hard maple species group had the largest increase in growing-stock volume—26 percent—by adding nearly 70 million cubic feet between 1980 and 1993. The largest percent of increase occurred in the red pine species group, rising from 42.8 million cubic feet in 1980 to 74.5 million cubic feet in 1993, a 74-percent increase. The red pine increase was due, in part, to a large amount of ingrowth

Table A.—*Number of all live trees on timberland by diameter class, average number of trees per acre, and percent of change per acre between inventories, Ottawa National Forest, 1980 and 1993*

Diameter class *(Inches)*	**No. of trees 1980** *(In thousand)*	**Aver. no. of trees/ acre** (822,700 acres)	**No. of trees 1993** *(In thousand)*	**Aver. no. of trees/ acre** (858,400 acres)	**Percent change/ acre 1980-1993**
1.0 - 4.9	422,571	513.6	447,478	521.3	2
5.0 - 8.9	127,488	155.0	109,849	128.0	(17)
9.0 - 12.9	32,783	39.8	39,160	45.6	15
13.0 - 16.9	9,421	11.5	11,242	13.1	14
17 +	3,831	4.7	5,027	5.9	26
All classes	596,094	724.6	612,756	713.8	(1)

into the merchantable-size class in addition to the growth on trees already in the merchantable-size class. In 1993, four species groups—hard maple, soft maple, quaking aspen, and red pine—accounted for 52 percent of the Forest's growing-stock volume (fig. 7).

Although total growing-stock volume increased between inventories, volume for some species groups decreased. Most notable was the drop in quaking aspen volume, largely due to removals and mortality. Between inventories, removals were nearly twice net annual growth and mortality was nearly equal to growth. Further, quaking aspen dropped from 13 percent of the total growing-stock volume on the Ottawa in 1980, to 9 percent in 1993. Between inventories, quaking aspen growing-stock volume decreased by 39.1 million cubic feet or 27 percent. Balsam fir growing-stock volume declined by 21.9 million cubic feet—a 26-percent drop. Balsam fir mortality was extremely high, accounting for about a fourth of the total mortality on the Forest. Mortality in balsam fir was about three times the volume of removals. Other species groups that decreased in growing-stock volume were: balsam poplar by 33 percent, bigtooth aspen by 30 percent, black spruce by 19 percent, yellow birch by 16 percent, and elm by 98 percent. All other species groups increased in growing-stock volume between inventories.

Sawtimber volume on the Ottawa increased from 2.9 billion board feet in 1980, to 3.5 billion board feet in 1993—a 22-percent increase. Twelve percent of the total sawtimber volume was in trees larger than 21 inches d.b.h. Species groups with the greatest proportion of sawtimber volume in larger than 21-inch-d.b.h. trees were white pine (46 percent), hemlock (28 percent), hard maple (20 percent), and yellow birch (12 percent).

FACTORS ASSOCIATED WITH RECENT CHANGE IN THE TIMBERLAND RESOURCES

Many factors can influence the composition and structure of timberland. In the past, logging and fire drastically altered the forest landscape. Most of the recent change to the forest landscape has come from the interactions between management activities, natural succession, and, to a lesser extent, natural

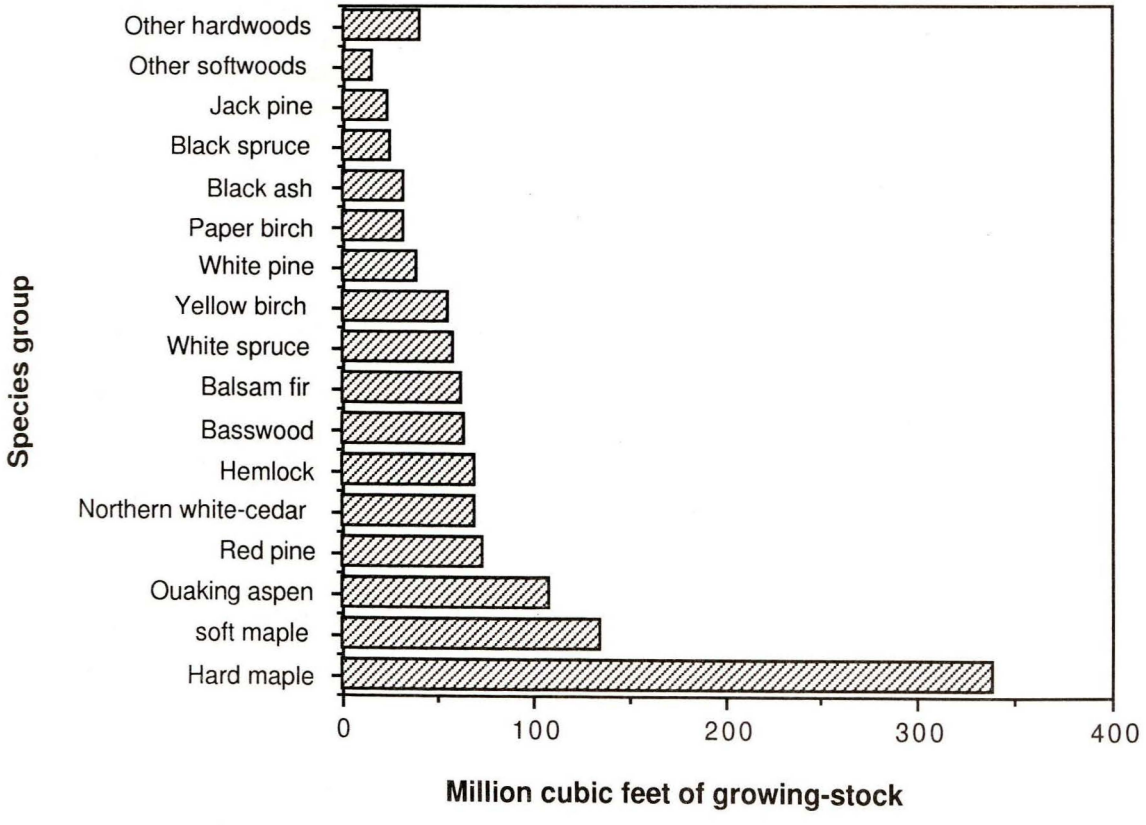

Figure 7.—*Growing-stock volume by species group on the Ottawa National Forest, 1993.*

disturbances. An analysis of average annual change in growth, mortality, and removals provides information about factors that influenced some of the change in the timberland resources of the Forest.

Average annual gross growth (average net annual growth plus mortality) on the Ottawa amounted to 39.3 million cubic feet for growing stock. In terms of sawtimber volume, growth was 144.5 million board feet between 1980 and 1992 (fig. 8). Annual mortality averaged 12.2 million cubic feet for growing stock, including 27.5 million board feet for sawtimber. In addition, 13.1 million cubic feet of growing stock, including 32.6 million board feet of sawtimber, were removed from the Ottawa annually between 1980 and 1992. The net increase in volume (gross growth minus mortality and removals) on the Ottawa averaged 14 million cubic feet of growing stock, including 84 million board feet of sawtimber, each year between 1980 and 1992. On an average per acre basis, there was a net increase (gross growth minus mortality and removals) of 16 cubic feet of growing stock per acre per year on the Ottawa.

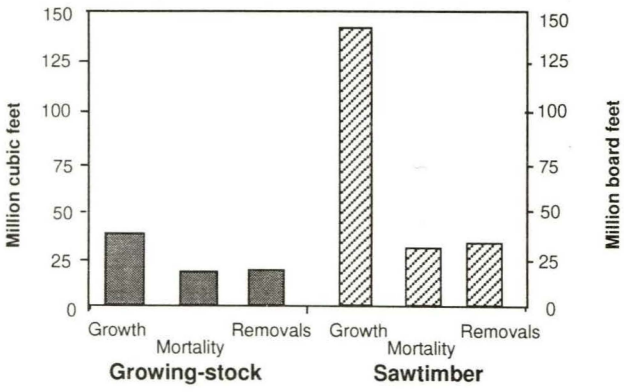

Figure 8.—*Average annual gross growth, mortality, and removals of growing stock and sawtimber on timberland on the Ottawa National Forest between 1980 and 1992.*

The timber resource on the Ottawa is healthy growing wood fiber at an annual rate that is comparable to the region as a whole and to the nearby Hiawatha National Forest. (See Leatherberry 1994, and Schmidt and Lanasa 1995, for statistical data for the Western Upper Peninsula Unit and the Hiawatha National Forest, respectively.) Removals are less than half of net annual growth and mortality is nearly equal to removals.

Harvesting timber is an important management tool that is used to meet commodity needs and to develop and maintain desired ecological conditions. The amount of timber harvested on the Ottawa is reflected in the average annual removals data (see table 14 in Appendix). Together, aspen and hard maple accounted for more than half (58 percent) of the 13.1 million cubic feet average annual removals of growing stock on the Ottawa. Average annual growing-stock removals of more than 1 million cubic feet per year on timberland occurred (in descending order of volume) in the aspen, hard maple, and balsam fir species groups. The aspen and hard maple species groups accounted for more than half (56 percent—18.4 million board feet) of the average annual sawtimber removals. Balsam fir (3.1 million board feet) and jack pine (2 million board feet) were also important sources of wood.

Average annual removals of sawtimber (32.6 million board feet) as a percent of average net annual growth (117 million board feet) on the Ottawa was 28 percent. Removals for balsam fir and balsam poplar exceeded growth. Species groups for which sawtimber removals were more than 50 percent of growth were jack pine (61 percent), aspen (65 percent), and black spruce (70 percent). The relative high removals rate is primarily due to the large acreage of old stands in these forest types, especially jack pine and aspen. On the other hand, red pine, much of it planted during the Civilian Conservation Corps days and the 1960's, was not extensively harvested, but has a tremendous potential as a future timber resource. As noted earlier, between inventories, red pine had the largest percentage increase (74 percent) in growing-stock volume. Red pine sawtimber volume increased by 281 percent (194.2 million board feet) between inventories. Average annual removals of red pine sawtimber as a percentage of average net annual growth was only 3 percent. The harvest of red pine that took place was mostly commercial thinnings to improve growth and quality of residual trees. Yields were primarily in small roundwood products rather than in sawtimber. In the coming years, more red pine will be available for harvest and will yield a

higher percentage of sawtimber as these stands put on rapid growth from the thinnings and grow into the sawtimber-size class.

The dynamic nature of forests creates situations in which not all species thrive simultaneously. Depending on the particular reproduction and growth habits of a species, it may not be able to compete effectively with other species for light, water, and nutrients. Aspen is a species that is declining on the Ottawa. The area of aspen on the Ottawa peaked around 1960 and has declined since (see figure 2). The decline of aspen is of particular interest because of its use in the forest products industry, and its importance as habitat for wildlife and game birds. An analysis of age class structure suggests that the decline of aspen on the Ottawa is due to old aspen stands deteriorating and converting to more shade-tolerant understory species, and to the relatively low rate of regeneration of aspen stands. For instance, between inventories, area of aspen stands more than 80 years old increased as a result of stands not being harvested because of their advanced age, poor access, or other resource considerations. Also, many older stands are not harvested because they contain defective timber that has reduced value and marketability. In 1993, 16 percent of the area (21,200 acres) in the aspen type was 61 years of age and older. Between 1980 and 1992, aspen mortality was nearly equal to growth. Further, in 1993, about 70 percent (94,300 acres) of aspen supported a natural balsam understory. Those older stands with balsam in the understory will probably convert to balsam fir or hard maple. Mortality will also affect young stands as natural thinning increases as the stand matures.

Balsam fir is a short-lived species and the effects of natural succession are apparent on the Ottawa where 69 percent (34,100 acres) of balsam fir type is in stands over 41 years old. Heart rot and butt rot can begin in balsam fir as early as 40 years and increase as the trees get older (Burns and Honkala 1990). The older balsam fir stands on the Ottawa apparently suffer from fungi-induced rot and other agents that cause mortality. During the period 1980-1993, average annual mortality of balsam fir was 3.0 million cubic feet, compared to only 107 thousand cubic feet of average net annual growth. In fact, balsam fir was responsible for one-fourth of the average net annual mortality for growing stock on the Forest. Mortality in balsam fir was about three times the volume of removals.

Elms declined between inventories with Dutch elm disease eliminating most of the larger elm trees on the Forest. Average net annual growth for elm was a minus 1.5 million cubic feet. A negative average net annual growth is the result of mortality volume being greater than growth volume. Other species for which average annual mortality exceeded net annual growth of growing stock were yellow birch, paper birch, and black spruce.

SUMMARY

Our analysis of the timberland resource on the Ottawa National Forest shows a diverse array of tree species on the Forest. Between 1980 and 1993, timberland area on the Ottawa expanded, the number of live trees increased, species composition was dynamic, trees in stands generally grew larger and older, growing-stock volume increased, and average net annual growth was more than double average annual removals. All of this points out that the Ottawa National Forest's timberland resource is healthy, and ecologically diverse. The present condition of the timberland resource is the result of years of good management. In the future, managers on the Ottawa will be challenged to manage the resource to promote the sustainability of its ecosystems while providing a supply of goods and services to an expanding population with diverse demands. This is no small challenge, but, current trends indicate the timberland resource of the Ottawa National Forest is capable of providing goods and services needed or demanded by society—while maintaining the ecological integrity of the resource.

APPENDIX

Note: *The 1993 inventory represents the fifth inventory of the forest resources of Michigan's Upper Peninsula where the Ottawa National Forest is located. The four previous forest resource inventories are dated 1935, 1955, 1966, and 1980. Data from new forest inventories are often compared with data from earlier inventories to determine trends in forest resources. However, for the comparison to be valid, the procedures and definitions used in the two inventories must be similar. As a result of our ongoing efforts to improve the inventory's efficiency and reliability, we have made several changes in procedures and definitions since the last Michigan inventory in 1980. Because some of these changes make it inappropriate to directly compare the 1993 data with those published for the region in 1980, data from the 1980 inventory have been re-processed using the current procedures. Forest inventories completed before 1980 have not been adjusted to reflect current FIA inventory methodology and techniques. Comparisons between inventories should be general and used solely for analyzing trends. All area and volume data and tables were based on what existed as of January 1, 1993, in the Ottawa National Forest. The time period used for growth, mortality, and removals was January 1, 1980, to December 31, 1992.*

ACCURACY OF THE SURVEY

Forest Inventory and Analysis (FIA) information is based on a sampling procedure designed to provide reliable statistics at the State and Survey Unit levels. Consequently, the reported figures are estimates only. A measure of reliability of these figures is given by sampling errors. The level of sampling error used by FIA means the chances are two out of three that if a 100-percent inventory had been taken, using the same methods, the results would have been within the limits indicated.

For example, the estimated growing-stock volume in the Ottawa National Forest in 1993, 1,262.3 million cubic feet, has a sampling error of ± 3.27 percent (± 41.3 million cubic feet). Based on this sampling error, growing-stock volume from a 100-percent inventory would be expected to fall between 1,221.0 and 1,303.6 million cubic feet (1,262.3 ± 41.3), there being a one in three chance that this is not the case. The following tabulation shows the sampling errors for the Ottawa National Forest:

Item	Unit totals	Sampling error
Growing stock	(Million cubic feet)	(Percent)
volume (1993)	1,262.3	3.27
Average annual growth (1980-1992)	27.1	5.58
Average annual removals (1980-1992)	13.1	18.29
Sawtimber	(Million board feet)	
volume (1993)	3,359.4	4.64
Average annual growth (1980-1992)	117.0	5.94
Average annual removals (1980-1992)	32.6	20.18
	(Thousand acres)	
Timberland area (1993)	858.4	1.43

Care must be taken when using data from below the National Forest level because of increased sampling errors. For example, the sampling error for timberland area in a District or Management Area is higher than that for total timberland area in the total National Forest. The tabulation on the previous page shows the sampling errors for National Forest totals. To estimate sampling error for data smaller than National Forest, use the following formula:

$$E = \frac{(SE)\sqrt{(\text{State total volume or area})}}{\sqrt{(\text{Volume or area smaller than State total})}}$$

Where:

E = Sampling error in percent.

SE = State total error for volume or area.

For example, to compute the error on the area of timberland in the maple-beech-birch type for the National Forest, proceed as follows:

1. Total area of timberland in the maple-beech-birch forest type from table 3 = 457,100 acres;
2. Total area of all timberland in the Ottawa National Forest from table 3 = 858,400 acres;
3. Ottawa National Forest total error for timberland area from the tabulation on the previous page = 1.43 percent.
4. Using the above formula:

$$E = \frac{(1.43)\sqrt{858{,}400}}{\sqrt{457{,}100}} = \pm 1.96 \text{ percent.}$$

SURVEY PROCEDURES

The 1993 survey of the Ottawa National Forest used a growth-model enhanced, two-phase sample design. Using this sampling scheme and associated estimators is similar to sampling with partial replacement, in that a set of randomly located plots is available for remeasurement and a random set of new plots is established and measured. A significant feature of the new design is stratification for disturbance on the old sample and use of a growth model to improve regression estimates made on old undisturbed forest plots (fig. 9). Detailed descriptions of the sampling and estimation procedures are presented by Hansen (1990). The growth model used was the Lake States Stand and Tree Evaluation and Modeling System (STEMS) (Belcher *et al.* 1982).

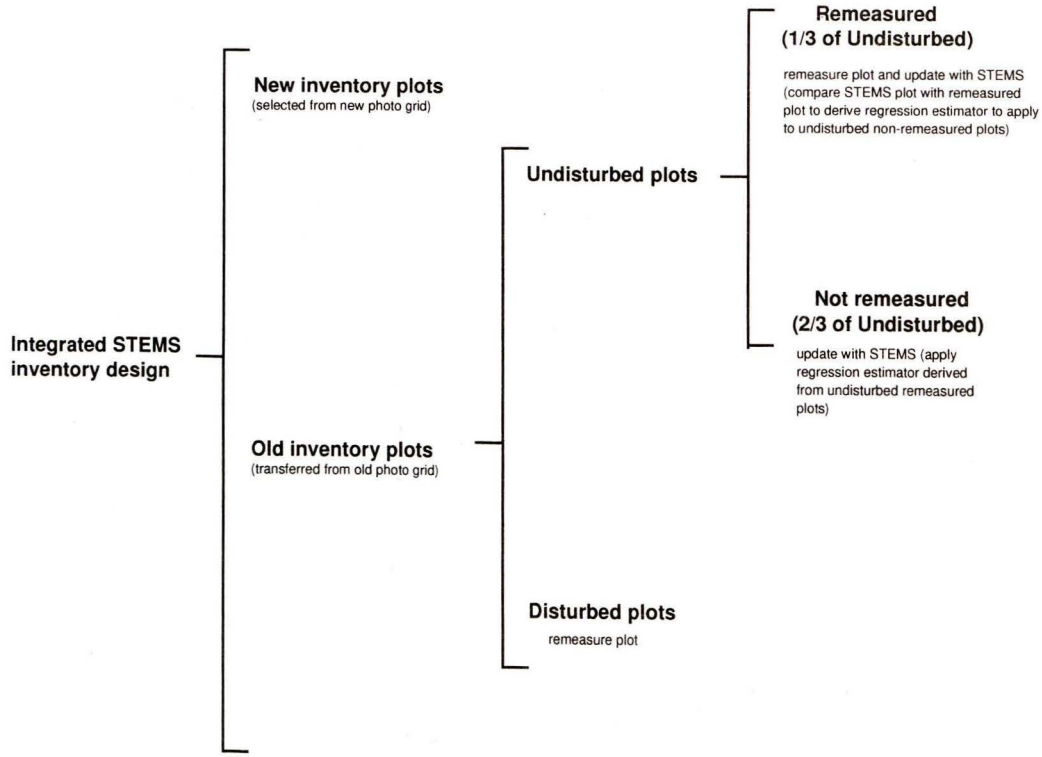
Integrated STEMS inventory design
New inventory plots
(selected from new photo grid)
Old inventory plots
(transferred from old photo grid)
Undisturbed plots
Remeasured
(1/3 of Undisturbed)
remeasure plot and update with STEMS (compare STEMS plot with remeasured plot to derive regression estimator to apply to undisturbed non-remeasured plots)
Not remeasured
(2/3 of Undisturbed)
update with STEMS (apply regression estimator derived from undisturbed remeasured plots)
Disturbed plots
remeasure plot

Figure 9.—*Sample design for the Ottawa National Forest 1993 survey.*

Major Steps in the New Survey Design

1. Aerial photography (Phase 1)

In this phase, two sets of random points were located on current aerial photographs. The first set was new photo plots, and the second set was relocated, old ground plot locations from the 1980 inventory. Locations of the plots used in the 1980 inventory were transferred to the new photographs. The photographs were then assembled into township mosaics, and a systematic grid of 121 one-acre photo plots (each plot representing approximately 190.4 acres) was overlaid on each township mosaic. Each photo plot was examined by aerial photogrammetrists and classified stereoscopically as to its land use. If trees were present, forest type and stand-size/density classes were recorded. All of the 1980 ground plot locations were also examined for disturbance (logging, fire, catastrophic mortality, etc.). After this examination, all the old "disturbed" sample locations and one-third of the old "undisturbed" forested plots were sent to the field for survey crews to verify the photo classification and to take further measurements. All photo plot locations for the 1993 inventory were examined and classified as shown in the following tabulation:

Photo land class	Photo plots
Timberland	4,428
Reserved forest land	252
Other forest land	0
Questionable	78
Nonforest with trees	40
Nonforest without trees	223
Water	0
All classes	5,021

2. Plot measurements (Phase 2)

On plots classified as timberland, wooded pasture, or windbreak (at least 120 feet wide), a ground plot was established, remeasured, or modeled. Old plots sent to the field for remeasurement that could not be relocated were replaced with a new plot at the approximate location of the old one. Each ground plot consisted of a 10-point cluster covering approximately 1 acre. At each point, trees 5.0 inches or more in diameter at breast height (d.b.h.) were sampled on a 37.5 basal area factor variable-radius plot, and trees less than 5.0 inches d.b.h. were sampled on a 1/300-acre fixed-radius plot. The measurement procedure for both the new and old sample locations was as follows:

a. New inventory plots

A random sample of the new photo plots was selected for field measurement. Ground plots were established, and measures of current classification such as land use, forest type, and ownership, as well as size and condition of all trees on the plot, were recorded. These locations were monumented for future remeasurement.

b. Old inventory plots

These plots were originally established, monumented, and measured as part of the 1980 field inventory. Procedures for these old plots were different from those for the new plots. Old plots were classed as "undisturbed" or "disturbed" in the aerial photo phase of the sampling process. All disturbed plots, and a one-third sample of the undisturbed forested plots, were remeasured to obtain estimates of current condition and changes since the last inventory. All trees measured on these plots in 1980 were remeasured or otherwise accounted for, and all new trees were identified and measured.

All sample plots that were forested at the time of the 1980 inventory and determined to be undisturbed until the 1993 inventory were projected to 1993 using STEMS. This procedure gives projected estimates of current volume and growth for undisturbed plots. Comparison of the projected and observed values on the one-third sample of the undisturbed forest plots that were remeasured provided local calibration data to adjust the projected values of the undisturbed plots that were not remeasured. The adjustment procedure is a modified version of the method described by Smith (1983).

Undisturbed forested plots that were not remeasured played a crucial role in the new survey design. These plots, after careful examination comparing past and current aerial photography, were determined to be undisturbed and had conditions that could be simulated by STEMS. The STEMS growth

model was used to "grow" the old plot and tree data to produce an estimate of current data. Thus, these plots were treated as ground plots, even though they were never visited.

All old plots classified as disturbed were sent to the field for remeasurement to assess and verify changes since the last inventory. Disturbance referred to any change on a plot that was detected on aerial photos and that the STEMS growth processor could not predict, such as catastrophic mortality, cutting, seedling stands, and/or land use change.

The estimation procedure for computing statistics from this sampling design was more complicated than the simple two-phase estimation procedure used in the past. In fact, this procedure yielded two independent samples, one coming from the new photo points and the other from the old photo points that were remeasured or modeled. The tabulation below summarizes the distribution of all ground plots for the new inventory design by type of plot.

3. Area estimates

Area estimates were made using two-phase estimation methods. In this type of estimation, a preliminary estimate of area by land use is made from the aerial photographs (Phase 1) and corrected by the plot measurements (Phase 2). A complete description of this estimation method is presented by Loetsch and Haller (1964). All area estimates were based on what existed as of January 1, 1993, in the Ottawa National Forest.

4. Volume estimates

Estimates of volume per acre were made from the trees measured or modeled on the 10-point plots. Estimates of volume per acre were multiplied by the area estimates to obtain estimates of total volume. Volume estimates were based on what existed as of January 1, 1993, in the Ottawa National Forest. Net cubic foot volumes were based on a modification of the method presented by Hahn (1984) for use in the Lake States. The merchantable height equation presented was used in conjunction with Hahn's board foot volume equation (Hahn 1984) to estimate gross volume. This estimate was then corrected by species for variation in bark thickness and cull volume to yield an estimate of net volume.

The Forest Service reports all board foot volume in International 1/4-inch rule. In Michigan, where the Ottawa National Forest is located, the Scribner log rule is commonly used. Scribner log rule conversion factors were derived from full tree measurements taken throughout the Lake States (Michigan, Wisconsin, and Minnesota) and an equation developed by Wiant and Castenaeda (1977). Factors, or multipliers, that can be used to convert board foot International volumes to the Scribner rule are shown in the following tabulation:

D.b.h. (inches)	Scribner rule conversion factor	
	Softwoods	Hardwoods
9.0-10.9	0.7830	—
11.0-12.9	.8287	0.8317
13.0-14.9	.8577	.8611
15.0-16.9	.8784	.8827
17.0-18.9	.8945	.8999
19.0-20.9	.9079	.9132
21.0-22.9	.9168	.9239
23.0-24.9	.9240	.9325
25.0-26.9	.9299	.9396
27.0-28.9	.9321	.9454
29.0+	.9357	.9544

Ground land use class	Old plots remeasured	Old plots updated	New plots	Total plots
Timberland	200	8	120	328
Reserved forest land	7	0	51	58
Nonforest with trees	1	0	2	3
Nonforest without trees	9	0	7	16
Noncensus water	1	0	4	5
Total	218	8	184	410

5. Growth and mortality estimates

On remeasured plots, estimates of growth and mortality per acre come from the remeasured diameters of trees and from observation of trees that died between inventories. Growth reported as the average net annual growth between the two inventories (1980 and 1992) was computed from data on remeasurement plots and modeled plots using methods presented by VanDeusen *et al.* (1986). Mortality was also reported as average annual for the remeasurement period. On new plots, where trees were not remeasured, estimates of growth and mortality were obtained by using STEMS to project the growth and mortality of trees for 1 year. Growth and mortality estimates for old undisturbed plots that were updated were derived in the same manner as remeasured plots. The STEMS growth model was adjusted to meet local conditions, using data from the undisturbed remeasurement plots. As with volume, total growth and mortality estimates were obtained by multiplying the per acre estimates by area estimates. Current annual growth for 1992 was computed by using the adjusted STEMS model to grow all current inventory plots for 1 year. All growth and mortality estimates were based on growth and mortality through December 31, 1992, in the Ottawa National Forest.

6. Average annual removals estimates

Average annual growing-stock and sawtimber removals (1980 to 1992) were estimated only from the remeasured plots; new plots were not used to estimate removals. These estimates were obtained from trees measured in the last survey and cut or otherwise removed from the timberland base. All removal estimates were based on removals through December 31, 1992, in the Ottawa National Forest. Because remeasurement plots make up about one-half of the total ground plots, average annual removals estimates have greater sampling errors than volume and growth estimates.

TREE AND LOG GRADES

On approximately one-third of the sample plots in the Ottawa National Forest, all sawtimber sample trees were graded for quality and assigned either a tree grade (hardwoods) or a log grade (softwoods). Tree and log grades were based on the evaluation of external characteristics as indicators of quality. The volume yield by grade for this sample was used to distribute the volume of the ungraded sample trees by species group. Hardwood sawtimber trees were graded according to "Hardwood Tree Grades for Factory Lumber" (Hanks 1976). The best 12-foot section of the lowest 16-foot hardwood log was used for grading. Hardwood sawtimber trees that did not meet minimum tree grade specifications for grades 1 through 3 were assigned grade 4 according to Forest Service standard specifications for hardwood construction logs described in "A Guide to Hardwood Log Grading" (Rast *et al.* 1973). Red pine and jack pine sawtimber trees were graded based on specifications described in "Forest Service Log Grades for Southern Pines" (Campbell 1964). White pine and other softwood sawtimber trees were graded according to specifications described in " Sawlog Grades for Eastern White Pine" (Ostrander and Brisbin 1971). For all softwoods, the first merchantable 16-foot log, or shorter lengths down to 12 feet, was used for grading.

Hardwood Tree Grades for Factory Lumber [a]

Grade factor	Tree grade 1	Tree grade 2	Tree grade 3
Length of grading zone (feet)	Butt 16	Butt 16	Butt 16
Length of grading section [b] (feet)	Best 12	Best 12	Best 12
D.b.h., minimum (inches)	16[c]	13	11
Diameter, minimum inside bark at top of grading section (inches)	13[c] 16 20	11[d] 12	8
Clear cuttings (on the three best faces):[d]			
Length, minimum (feet)	7 5 3	3 3	2
Number on face (maximum)	2	2 3	f
Yield in face length (minimum)	5/6	4/6	3/6
Cull deduction (including crook and sweep, but excluding shake) maximum within grading section (percent)	9	9g	50

a Hanks (1976)

b Whenever a 14- or 16-foot section of the butt 16-foot log is better than the best 12-foot section, the grade of the longer section will become the grade of the tree. This longer section, when used, is the basis for determining the grading factors.

c In basswood and ash, diameter inside bark (d.i.b.) at top of grading section must be 12 inches and d.b.h. must be 15 inches.

d Grade 2 trees can be 10 inches d.i.b. at top of grading section if otherwise meeting surface requirements for small grade 1's.

e A clear cutting is a portion of a face free of defects, extending the width of the face. A face is one-fourth of the surface of the grading section as divided lengthwise.

f Unlimited.

g Fifteen percent crook and sweep or 40 percent total cull deduction are permitted in grade 2, if size and surface of grading section qualify as grade 1. If rot shortens the required clear cuttings to the extent of dropping the butt log to grade 2, do not drop the tree's grade to 3 unless the cull deduction for rot is greater than 40 percent.

Forest Service Standard Specifications for Hardwood Construction Logs (tie and timber logs) [a] [b]

Position in tree	Butts and uppers
Min. diameter, small end	8 inches +
Min. length without trim	8 feet +
Clear cuttings	No requirements
Sweep allowance	One-fourth small end d.i.b. for each 8 feet of length. One-half d.i.b. for logs 16 feet long.
Sound surface defects:	
Single knots	Any number, if no knot has an average diameter above the callus in excess of one-third of the log diameter at point of occurrence.
Whorled knots	Any number, if the sum of knot diameters above the callus does not exceed one-third of the log diameter at point of occurrence.
Holes	Any number not exceeding knot specifications as long as they do not extend over 3 inches into contained tie or timber.
Unsound defects :	
Surface	Same requirements as for sound defects if they extend into included timber. No limit if they do not.
Interior	None permitted except one shake not more than one-third the width of contained tie or timber, and one split, not over 5 inches.

a These specifications are minimum for the class. If, from a group of logs, factory logs are selected first, thus leaving only nonfactory logs from which to select construction logs, then the quality range of the construction logs so selected is limited, and the class may be considered a grade. If selection for construction logs is given first priority, it may be necessary to subdivide the class into grades.

b Rast *et al.* (1973).

Log Grades for Jack Pine and Red Pine [a]

Grade 1: Logs with three or four clear faces on the 16-foot grading section. [b]

Grade 2: Logs with one or two clear faces on the 16-foot grading section.

Grade 3: Logs with no clear faces on the 16-foot grading section.

After the tentative grade is established from above, the log will be reduced one grade for each of the following defects, except that no log can be reduced below grade 3. Net scale after deduction for defect must be at least 50 percent of the gross contents of the log.

1. **Sweep**. Degrade any tentative grade 1 or 2 log one grade if sweep amounts to 3 or more inches and equals or exceeds one-third of the diameter inside bark at the small end.
2. **Heart rot**. Degrade any tentative grade 1 or 2 log one grade if conk, punk knots, massed hyphae, or other evidence of advanced heart rot is found anywhere on the log.

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a Campbell (1964).

b A face is one-fourth of the circumference in width extending full length of the log. Clear faces are those free of: knots measuring more than 1/2-inch in diameter, overgrown knots of any size, and holes more than 1/4-inch in diameter. Faces may be rotated to obtain the maximum number of clear ones.

Eastern White Pine Saw Log Grade Specifications [a]

Grading Factor	Log Grade 1	Log Grade 2	Log Grade 3	Log Grade 4
1. Minimum Scaling Diameter (inches)	14 [b]	6	6	6
2. Minimum Log Length (feet)	10 [c]	8	8	8
3. Maximum Weevil Injury (number)	None	None	2 Injuries [d]	No Limit
4. Minimum Face Requirements	Two full length or four 50% [e] good faces (in length addition, log knots on balance of faces shall not exceed size limits of grade 2 logs).	NO GOOD FACES REQUIRED Maximum diameter of log knots on three best faces: SOUND RED KNOTS not to exceed 1/6 scaling diameter and 3 inch maximum. DEAD OR BLACK KNOTS including overgrown knots not to exceed 1/12 scaling diameter and 1 1/2 inch maximum.	SOUND RED Knots not to exceed 1/3 scaling diameter and 5 inch maximum. DEAD OR BLACK KNOTS including overgrown knots not to exceed 1/6 scaling diameter and 2 1/2 inch maximum.	Includes all logs not qualifying for No. 3 or better and have at least 1/3 of their gross volume in sound wood suitable for manufacture into standard lumber.
5. Maximum sweep or crook allowance (%)	20	30	40	66 2/3
6. Maximum total scaling deduction (%)	50	50	50	66 2/3

AFTER THE TENTATIVE LOG GRADE IS ESTABLISHED FROM FACE EXAMINATION, THE LOG WILL BE REDUCED IN GRADE WHENEVER THE FOLLOWING DEFECTS ARE EVIDENT.

7. Conks, punk knots, and pine borer damage on bark surface [f].
   Degrade one grade if present on one face.
   Degrade two grades if present on two faces.
   Degrade three grades if present on three or more faces.

8. Log end defects: red rot, ring shake, heavy stain, and pine borer damage outside the heart center of log[e].
   Consider log as having a total of 8 quarters (4 on each end) and degrade as indicated.
   Degrade one grade if present in 2 quarters of log ends.
   Degrade two grades if present in 3 or 4 quarters of log ends.
   Degrade three grades if present in 5 or more quarters of log ends.

a. 12- and 13-inch logs with four full length good faces are acceptable.
b. 8-foot logs with four full length good faces are acceptable.
c. 8-foot Number 3 logs limited to one weevil injury.
d. Minimum 50% length good face must be at least 6 feet.
e. Factors 7 and 8 are not cumulative (total degrade based on more serious of the two). No log to be degraded below grade 4 if net scale is at least one-third of gross scale.

Log Grades for All Other Softwood Logs

Grade 1

1. Logs must be 16 inches d.i.b. or larger, 10 feet in length or longer, and with deduction for defect, not over 30 percent of gross scale.
2. Logs must be at least 75 percent clear on each of three faces.
3. All knots outside clear cuttings must be sound and not more than 2-1/2 inches in size.

Grade 2

1. Logs must be 12 inches d.i.b. or larger, 10 feet in length or longer, and with a net scale after deduction for defect of at least 50 percent of the gross contents of the log.
2. Logs must be at least 50 percent clear on each of three faces or 75 percent clear on two faces.

Grade 3

1. Logs must be 6 inches d.i.b. or larger, 8 feet in length or longer, and with a net scale after deduction for defect of at least 50 percent of the gross contents of the log.

Note: Diameters are d.i.b. at small end of grading section and percent clear refers to percent clear in one continuous section.

METRIC EQUIVALENTS OF UNITS USED IN THIS REPORT

1 acre = 4,046.86 square meters or 0.405 hectare.
1,000 acres = 405 hectares.
1 cubic foot = 0.0283 cubic meter.
1 foot = 30.48 centimeters or 0.3048 meter.
1 inch = 25.4 millimeters, 2.54 centimeters, or 0.0254 meter.
1 pound = 0.454 kilogram.
1 ton = 0.907 metric ton.

TREE SPECIES IN THE OTTAWA NATIONAL FOREST[1]

SOFTWOODS

Balsam fir ..... *Abies balsamea*
Tamarack ..... *Larix laricina*
White spruce ..... *Picea glauca*
Black spruce ..... *Picea mariana*
Jack pine ..... *Pinus banksiana*
Red pine ..... *Pinus resinosa*
Eastern white pine ..... *Pinus strobus*
Northern white-cedar ..... *Thuja occidentalis*
Eastern hemlock ..... *Tsuga canadensis*
Other softwoods
  Engelmann spruce ..... *Picea engelmannii*
  Eastern redcedar ..... *Juniperus virginiana*
  Scotch pine ..... *Pinus sylvestris*

HARDWOODS

Hard maple[2]
  Sugar maple ..... *Acer saccharum*
Soft maple[3]
  Red maple ..... *Acer rubrum*
Yellow birch[2] ..... *Betula alleghaniensis*
Paper birch[3] ..... *Betula papyrifera*
American beech[3] ..... *Fagus grandifolia*
White ash[2] ..... *Fraxinus americana*
Black ash[3] ..... *Fraxinus nigra*
Green ash[2] ..... *Fraxinus pennsylvanica*
Butternut[3] ..... *Juglans cinerea*
Balsam poplar[3] ..... *Populus balsamifera*
Bigtooth aspen[3] ..... *Populus grandidentata*
Quaking aspen[3] ..... *Populus tremuloides*
Black cherry[3] ..... *Prunus serotina*
Select white oaks[2]
  White oak ..... *Quercus alba*
  Swamp white oak ..... *Quercus bicolor*
Select red oaks[2]
  Northern red oak ..... *Quercus rubra*
American basswood[3] ..... *Tilia americana*
American elm[3] ..... *Ulmus americana*
Noncommercial species
  Striped maple ..... *Acer pennsylvanicum*
  Mountain maple ..... *Acer spicatum*
  Hawthorn ..... *Crataegus* spp.
  Eastern hophornbeam ..... *Ostrya virginiana*
  Canada plum ..... *Prunus nigra*
  Pin cherry ..... *Prunus pensylvanica*
  Wild plum ..... *Prunus* spp.
  Chokecherry ..... *Prunus virginiana*
  Willow spp. ..... *Salix* spp.

[1] *The common and scientific names are based on Little, Elbert L.*

[2] *This species or species group is considered a hard hardwood, with an average specific gravity greater than or equal to 0.50.*

[3] *This species or species group is considered a soft hardwood, with an average specific gravity of less than 0.50.*

DEFINITION OF TERMS

Average annual removals from growing stock.—The average net growing-stock volume in growing-stock trees removed annually for forest products (including roundwood products and logging residues) and for other uses. Average annual removals of growing stock are reported for a period of several years (1980 to 1992 in this report) and are based on information obtained from remeasure-ment plots (see Survey Procedures in Appendix).

Average annual removals from sawtimber.—The average net board foot sawtimber volume of live sawtimber trees removed annually for forest products (including roundwood products) and other uses. Average annual removals of sawtimber are reported for a period of several years (1980 to 1992 in this report) and are based on information obtained from remeasurement plots (see Survey Procedures in Appendix).

Average net annual growth of growing stock.—The annual change in volume of sound wood in live sawtimber and poletimber trees and the total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes.

Average net annual growth of sawtimber.—The annual change in the volume of live sawtimber trees and the total volume of trees reaching sawtimber size, less volume losses resulting from natural causes.

Basal area.—Tree area, in square feet, of the cross section at breast height of a single tree. When the basal areas of all trees in a stand are summed, the result is usually expressed as square feet of basal area per acre.

Butt log.—The first 12 to 16 feet from a 1-foot stump that could be, or is, cut. Minimum standards for butt logs vary by species.

Clear panel.—A section of hardwood tree surface one-fourth the circumference of the tree and at least 2 feet long, free of limbs, knots, bumps, and other indications of defect that preclude clear cuttings.

Commercial species.—Tree species presently or prospectively suitable for industrial wood products. (Note: Excludes species of typically small size, poor form, or inferior quality such as hophornbeam and redbud.)

Cull.—Portions of a tree that are unusable for industrial wood products because of rot, missing or dead material, or other defect.

Diameter class.—A classification of trees based on diameter outside bark, measured at breast height (d.b.h.). Two-inch diameter classes are commonly used in Forest Inventory and Analysis, with the even inch the approximate midpoint for a class. For example, the 6-inch class includes trees 5.0 through 6.9 inches d.b.h.

Diameter at breast height (d.b.h.).—The outside bark diameter at 4.5 feet (1.37 m) above the forest floor on the uphill side of the tree. For determining breast height, the forest floor includes the duff layer that may be present, but does not include unincorporated woody debris that may rise above the ground line.

Face.—A section of the tree surface one-fourth the circumference of the tree extending the full length of the log.

Forest land.—Land at least 16.7 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. (Note: Stocking is measured by comparing specified standards with basal area and/or number of trees, age or size, and spacing.) The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams, or other bodies of water or clearings in forest areas shall be classed as forest if less than 120 feet wide. (See definitions for Land, Timberland, Reserved forest land, Other forest land, Stocking, and Water.)

Forest type.—A classification of forest land based on the species forming a plurality of live tree stocking. Major forest types in the State are:

Jack pine.—Forests in which jack pine comprises a plurality of the stocking. (Common associates include eastern white pine, red pine, aspen, birch, and maple.)

Red pine.—Forests in which red pine comprises a plurality of the stocking. (Common associates include eastern white pine, jack pine, aspen, birch, and maple.)

Eastern white pine.—Forests in which eastern white pine comprises a plurality of the stocking. (Common associates include red pine, jack pine, aspen, birch, and maple.)

Balsam fir.—Forests in which balsam fir and white spruce comprise a plurality of the stocking with balsam fir the most common. (Common associates include white spruce, aspen, maple, birch, northern white-cedar, and tamarack.)

White spruce.—Forests in which white spruce and balsam fir comprise a plurality of the stocking with white spruce the most common. (Common associates include balsam fir, aspen, maple, birch, northern white-cedar, and tamarack.)

Black spruce.—Forests in which swamp conifers comprise a plurality of the stocking with black spruce the most common. (Common associates include tamarack and northern white-cedar.)

Northern white-cedar.—Forests in which swamp conifer species comprise a plurality of the stocking with northern white-cedar the most common. (Common associates include tamarack and black spruce.)

Tamarack.—Forests in which swamp conifers comprise a plurality of the stocking with tamarack the most common. (Common associates include black spruce and northern white-cedar.)

Oak-hickory.—Forests in which northern red oak, white oak, bur oak, or hickories, singly or in combination, comprise a plurality of the stocking. (Common associates include jack pine, beech, yellow-poplar, elm, and maple.)

Elm-ash-soft maple.—Forests in which lowland elm, ash, red maple, silver maple, and cottonwood, singly or in combination, comprise a plurality of the stocking. (Common associates include birch, spruce, and balsam fir.)

Maple-beech-birch.—Forests in which sugar maple, basswood, yellow birch, upland American elm, and red maple, singly or in combination, comprise a plurality of the stocking. (Common associates include birch, spruce, and balsam fir.)

Aspen.—Forests in which quaking aspen or bigtooth aspen, singly or in combination, comprise a plurality of the stocking. (Common associates include balsam poplar, balsam fir, and paper birch.)

Paper birch.—Forests in which paper birch comprises a plurality of the stocking. (Common associates include maple, aspen, and balsam fir.)

Balsam poplar.—Forests in which balsam poplar comprises a plurality of the stocking. (Common associates include aspen, elm, and ash.)

Growing-stock tree.—A live tree of commercial species that meets specified standards of size, quality, and merchantability. (Note: Excludes rough, rotten, and dead trees.)

Growing-stock volume.—Net volume in cubic feet of growing-stock trees 5.0 inches d.b.h. and over, from 1 foot above the ground to a minimum 4.0 inch top diameter (outside bark) of the central stem or to the point where the central stem breaks into limbs.

Hard hardwoods.—Hardwood species with an average specific gravity greater than 0.50 such as oaks, hard maple, and hickories.

Hardwoods.—Dicotyledonous trees, usually broad-leaved and deciduous. (See Soft hardwoods and Hard hardwoods.)

Land.—*(a) Bureau of the Census.* Dry land and land temporarily or partly covered by water such as marshes, swamps, and river flood plains (omitting tidal flats below mean high tide); streams, sloughs, estuaries, and canals less than one-eighth of a statute mile wide; and lakes, reservoirs, and ponds less than 40 acres in area.

(b) Forest Inventory and Analysis. The same as the Bureau of the Census, except minimum width of streams, etc., is 120 feet and minimum size of lakes, etc., is less than 1 acre.

Live trees.—Growing-stock, rough, and rotten trees 1.0 inch d.b.h. and larger.

Log grade.—A log classification based on external characteristics as indicators of quality or value. (See Appendix for specific grading factors used.)

Merchantable.—Refers to a pulpwood or saw-log section that meets pulpwood or saw-log specifications, respectively.

Mortality.—The volume of sound wood in growing-stock and sawtimber trees that die annually.

National Forest land.—Federal land that has been legally designated as National Forest or purchase units, and other land administered by the USDA Forest Service.

Net volume.—Gross volume less deductions for rot, sweep, or other defect affecting use for timber products.

Noncommercial species.—Tree species of typically small size, poor form, or inferior quality that normally do not develop into trees suitable for industrial wood products.

Nonforest land.—Land that has never supported forests, and land formerly forested where use for timber management is precluded by development for other uses. (Note: Includes areas used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining clearings, powerline clearings of any width, and 1- to 40-acre areas of water classified by the Bureau of the Census as land. If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet wide and more than 1 acre in area to qualify as nonforest land.)

a. Nonforest land without trees.—Nonforest land with no live trees present.

b. Nonforest land with trees.—Nonforest land with one or more trees per acre at least 5 inches d.b.h.

Nonstocked land.—Forest land less than 16.7 percent stocked with all live trees.

Other forest land.—Forest land not capable of producing 20 cubic feet per acre per year of industrial wood crops under natural conditions and not associated with urban or rural development. These sites often contain tree species that are not currently utilized for industrial wood production or trees of poor form, small size, or inferior quality that are unfit for industrial products. Unproductivity may be the result of adverse site conditions such as sterile soil, dry climate, poor drainage, high elevation, and rockiness. This land is not withdrawn from timber utilization.

Poletimber stand.—(See Stand-size class.)

Poletimber tree.—A tree of commercial species at least 5.0 inches d.b.h. but smaller than sawtimber size.

Potential productivity class.—A classification of forest lands in terms of inherent capacity to grow crops of industrial wood. The class identifies the potential growth in merchantable cubic feet/acre/year at culmination of mean annual increment of fully stocked natural stands.

Reserved forest land.—Forest land withdrawn from timber utilization through statute, administrative regulation, designation, or exclusive use for Christmas tree production, as indicated by annual shearing.

Rotten tree.—A tree that does not meet regional merchantability standards because of excessive unsound cull. May include noncommercial tree species.

Rough tree.—A tree that does not meet regional merchantability standards because of excessive sound cull. May include noncommercial tree species.

Roundwood products.—Logs, bolts or other round sections (including chips from roundwood) cut from trees for industrial or consumer uses. (Note: Includes saw logs, veneer logs and bolts; cooperage logs and bolts; pulpwood; fuelwood; pilings; poles; posts; hewn ties; mine timbers; and various other round, split, or hewn products.)

Salvable dead tree.—A standing or down dead tree considered merchantable by regional standards.

Sapling.—A live tree 1.0 to 5.0 inches d.b.h.

Sapling-seedling stand.—(See Stand-size class.)

Saw log.—A log meeting minimum standards of diameter, length, and defect. A saw log must be at least 8 feet long, sound, straight, have a minimum diameter outside bark (d.o.b.) of 7.0 inches for softwoods and 9.0 inches for hardwoods, or have other combinations of size and defect specified by regional standards.

Saw-log portion.—That part of the bole of sawtimber trees between the stump and the saw-log top.

Saw-log top.—The point on the bole of sawtimber trees above which a saw log cannot be produced. The minimum saw-log top is 7.0 inches d.o.b. for softwoods and 9.0 inches d.o.b. for hardwoods.

Sawtimber stand.—(See Stand-size class.)

Sawtimber tree.—A tree of commercial species containing at least a 12-foot saw log or two noncontiguous saw logs 8 feet or longer, and meeting regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d.b.h. Hardwoods must be at least 11.0 inches d.b.h.

Sawtimber volume.—Net volume of the saw-log portion of live sawtimber in board feet, International 1/4-inch rule (unless specified otherwise), from the stump to a minimum 7.0 inches top d.o.b. for softwoods and a minimum 9.0 inches top d.o.b. for hardwoods.

Seedling.—A live tree less than 1.0 inch d.b.h. that is expected to survive. Only softwood seedlings more than 6 inches tall and hardwood seedlings more than 1 foot tall are counted.

Short-log (rough tree).—Sawtimber-size trees of commercial species that contain at least one merchantable 8- to 11-foot saw log, but not a 12-foot saw log.

Site index.—An expression of forest site quality based on the height of a free-growing dominant, or codominant, tree of a representative species in the forest type at age 50.

Soft hardwoods.—Hardwood species with an average specific gravity less than 0.50 such as gum, yellow-poplar, cottonwood, red maple, basswood, and willow.

Softwoods.—Coniferous trees, usually evergreen, having needles or scale-like leaves.

Stand.—A group of trees on a minimum of 1 acre of forest land that is stocked by forest trees of any size.

Stand-age class.—Age of main stand. Main stand refers to trees of the dominant forest type and stand-size class.

Stand-size class.—A classification of stocked (see Stocking) forest land based on the size class of live trees on the area; that is, sawtimber, poletimber, or saplings and seedlings.

a. Sawtimber stands.—Stands with half or more of live stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

b. Poletimber stands.—Stands with half or more live stocking in poletimber and/or sawtimber trees, and with poletimber stocking exceeding that of sawtimber.

c. Sapling-seedling stands.—Stands with more than half of the live stocking in saplings and/or seedlings.

Stocking.—The degree of occupancy of land by live trees, measured by basal area; and/or the number of trees in a stand by size or age and spacing, compared to the basal area; and/or number of trees required to fully utilize the growth potential of the land; that is, the stocking standard.

A stocking percent of 100 indicates full utilization of the site and is equivalent to 80 square feet of basal area per acre in trees 5.0 inches d.b.h. and larger. In a stand of trees less than 5 inches d.b.h., a stocking percent of 100 would indicate that the present number of trees is sufficient to produce 80 square feet of basal area per acre when the trees reach 5 inches d.b.h.

Stands are grouped into the following stocking classes:

Overstocked stands.—Stands in which stocking of live trees is 133 percent or more.

Fully stocked stands.—Stands in which stocking of live trees is from 100.0 to 132.9 percent.

Medium stocked stands.—Stands in which stocking of live trees is from 60.0 to 99.9 percent.

Poorly stocked stands.—Stands in which stocking of live trees is from 16.7 to 59.9 percent.

Nonstocked areas.—Timberland on which stocking of live trees is less than 16.7 percent.

Timberland.—Forest land that is producing, or capable of producing, in excess of 20 cubic feet per acre per year of industrial wood crops under natural conditions. In addition, the forest land must not be withdrawn from timber utilization, and not associated with urban or rural development. Currently inaccessible and inoperable areas are included.

Tree.—A woody plant usually having one or more perennial stems, a more or less definitely formed crown of foliage, and a height of at least 12 feet at maturity.

Tree grade.—A tree classification based on external characteristics as indicators of quality or value, used for hardwood species. (See Appendix for specific grading factors used.)

Tree size class.—A classification of trees based on diameter at breast height, including sawtimber trees, poletimber trees, saplings, and seedlings.

Upper stem portion.—That part of the bole of sawtimber trees above the saw-log top to a minimum top diameter of 4.0 inches outside bark, or to the point where the central stem breaks into limbs.

Water.—*(a) Bureau of the Census.*—Permanent inland water surfaces, such as lakes, reservoirs, and ponds at least 40 acres in area;

and streams, sloughs, estuaries, and canals at least one-eighth of a statute mile wide.

(b) Noncensus.—Permanent inland water surfaces, such as lakes, reservoirs, and ponds from 1 to 39.9 acres in area; and streams, sloughs, estuaries, and canals from 120 feet to one-eighth of a statute mile wide.

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TABLE TITLES

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Table 1.--Area by county and major land-use class,
Ottawa National Forest, 1993

(In thousand acres)

County	Total land area	Forest land				Non-forest land
		All forest land	Timberland	Reserved timberland	Other forest land	
Baraga	44.6	44.6	33.7	10.9	-	-
Gogebic	311.7	282.6	267.1	15.5	-	29.1
Houghton	156.9	151.4	141.5	9.9	-	5.5
Iron	176.6	169.9	169.0	-	0.9	6.7
Marquette	13.0	13.0	-	13.0	-	-
Ontonagon	254.2	247.1	247.1	-	-	7.1
All counties	957.0	908.6	858.4	49.3	0.9	48.4

Table 2.--Area of timberland by forest type and stand-size class,
Ottawa National Forest, 1993

(In thousand acres)

Forest type [1]	All stands	Stand-size class		
		Sawtimber	Poletimber	Seedling & sapling
Jack pine	14.5	6.2	3.1	5.2
Red pine	52.4	26.8	15.9	9.7
White pine	11.7	9.3	-	2.4
Balsam fir	49.2	24.8	19.1	5.3
White spruce	15.9	4.0	5.9	6.0
Black spruce	25.0	4.5	8.9	11.6
Northern white-cedar	34.3	30.6	2.0	1.7
Tamarack	12.5	-	1.8	10.7
Oak-hickory	3.5	2.9	-	0.6
Elm-ash-soft maple	36.0	14.5	16.8	4.7
Maple-beech-birch	457.1	252.7	151.9	52.5
Aspen	134.5	34.8	16.0	83.7
Paper birch	10.5	-	10.5	-
Balsam poplar	1.3	-	-	1.3
All types	858.4	411.1	251.9	195.4

[1] This table is based on FIA forest type definitions, and data by stand-size class differ from that in the Ottawa Forest Stand Data Bases.

Table 3.--Area of timberland by forest type and potential productivity class, Ottawa National Forest, 1993

(In thousand acres)

Forest type	All classes	Potential productivity class (cubic feet of growth per acre per year) 120+ cu. ft.	85-119 cu. ft.	50-84 cu. ft.	Less than 49 cu. ft.
Jack pine	14.5	-	-	12.4	2.1
Red pine	52.4	25.6	19.5	7.3	-
White pine	11.7	2.4	5.2	2.7	1.4
Balsam fir	49.2	29.0	18.2	2.0	-
White spruce	15.9	-	3.1	12.8	-
Black spruce	25.0	-	2.1	10.3	12.6
Northern white-cedar	34.3	-	-	11.6	22.7
Tamarack	12.5	-	-	10.7	1.8
Oak-hickory	3.5	-	-	3.5	-
Elm-ash-soft maple	36.0	-	-	5.2	30.8
Maple-beech-birch	457.1	6.0	53.8	284.9	112.4
Aspen	134.5	7.6	62.3	54.4	10.2
Paper birch	10.5	-	-	7.6	2.9
Balsam poplar	1.3	-	-	1.3	-
All types	858.4	70.6	164.2	426.7	196.9

Table 4.--Area of timberland by forest type and stocking class of growing-stock trees[1], Ottawa National Forest, 1993

(In thousand acres)

Forest type	All classes	Stocking class		
		Poorly stocked	Moderately stocked	Fully stocked
Jack pine	14.5	-	1.5	13.0
Red pine	52.4	-	5.0	47.4
White pine	11.7	-	-	11.7
Balsam fir	49.2	-	9.0	40.2
White spruce	15.9	-	4.1	11.8
Black spruce	25.0	-	-	25.0
Northern white-cedar	34.3	0.9	-	33.4
Tamarack	12.5	-	4.9	7.6
Oak-hickory	3.5	0.6	-	2.9
Elm-ash-soft maple	36.0	8.1	13.9	14.0
Maple-beech-birch	457.1	2.7	80.2	374.2
Aspen	134.5	6.6	15.3	112.6
Paper birch	10.5	-	-	10.5
Balsam poplar	1.3	1.3	-	-
All types	858.4	20.2	133.9	704.3

[1] This table is based on the stocking percent of growing-stock trees, rather than that of all live trees. For this table, to use the definition of stocking found in the Appendix, replace the term "all live" by "growing-stock."

Table 5.--Number of all live trees on timberland by species group and diameter class, Ottawa National Forest, 1993

(In thousand trees)

Species group	All classes	Diameter class (Inches at breast height) 1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods													
Jack pine	5,554	1,401	867	630	1,480	876	183	105	12	-	-	-	-
Red pine	13,319	1,740	2,520	2,818	2,943	1,822	953	313	87	83	18	22	-
White pine	2,646	1,044	492	94	26	223	139	159	117	104	93	140	15
White spruce	17,436	6,987	4,536	2,423	1,419	828	507	382	167	148	26	13	-
Black spruce	18,378	7,257	5,805	3,259	1,455	517	59	12	11	3	-	-	-
Balsam fir	94,669	57,912	22,520	9,085	3,474	1,221	359	89	7	-	-	2	-
Hemlock	6,571	1,584	678	414	432	922	802	510	438	288	227	273	3
Tamarack	5,207	2,202	1,062	840	632	261	105	62	24	14	5	-	-
Northern white-cedar	16,441	3,732	2,325	3,131	2,256	2,497	1,072	828	305	177	50	68	-
Other softwoods	133	-	-	74	-	59	-	-	-	-	-	-	-
Total softwoods	180,354	83,859	40,805	22,768	14,117	9,226	4,179	2,460	1,168	817	419	518	18
Hardwoods													
Select white oak	50	-	-	-	-	-	22	28	-	-	-	-	-
Select red oak	1,704	486	141	152	290	185	229	89	57	35	28	12	-
Basswood	10,128	3,312	1,002	1,336	1,478	1,054	1,120	487	184	106	33	16	-
Yellow birch	16,933	4,965	4,565	2,572	1,728	1,261	560	435	347	236	137	110	17
Hard maple	145,698	72,621	29,722	18,812	11,556	6,289	2,762	1,381	946	751	399	444	15
Soft maple	78,058	35,301	19,541	11,355	5,700	3,136	1,430	774	449	236	83	53	-
Elm	2,619	2,238	252	102	-	-	-	-	15	9	-	3	-
Black ash	22,138	10,461	5,940	2,805	1,701	633	327	176	66	21	6	2	-
White & green ash	4,595	2,256	1,131	487	218	213	155	46	56	20	9	4	-
Balsam poplar	339	246	-	-	-	38	43	6	-	6	-	-	-
Bigtooth aspen	4,447	3,195	189	252	224	129	152	198	66	26	9	7	-
Quaking aspen	99,533	71,793	16,074	3,360	2,533	2,034	1,891	909	541	261	86	51	-
Paper birch	8,346	2,049	1,272	1,860	1,744	851	342	151	66	9	2	-	-
Black cherry	13,741	9,168	1,755	1,135	707	633	189	117	24	5	-	8	-
Other hardwoods	235	147	-	73	15	-	-	-	-	-	-	-	-
Noncommercial hardwoods	23,838	20,154	2,838	705	64	63	14	-	-	-	-	-	-
Total hardwoods	432,402	238,392	84,422	45,006	27,958	16,519	9,236	4,797	2,817	1,721	792	710	32
All species	612,756	322,251	125,227	67,774	42,075	25,745	13,415	7,257	3,985	2,538	1,211	1,228	50

Table 6.--Net volume of all live trees and growing-stock trees on timberland by Ranger District and major species group, Ottawa National Forest, 1993

Ranger district	All live trees					Growing-stock trees				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	Thousand cubic feet					*Thousand cubic feet*				
Bergland	217,858	624	49,123	67,297	100,814	191,642	624	44,599	57,179	89,240
Bessemer	220,920	14,580	62,457	69,578	74,305	187,609	14,580	56,874	57,560	58,595
Iron River	204,673	19,317	44,246	68,652	72,458	179,288	18,919	41,642	57,253	61,474
Kenton	277,704	56,979	64,879	83,805	72,041	247,252	55,549	60,839	68,647	62,217
Ontonagon	244,361	30,012	52,972	87,200	74,177	214,308	29,049	47,732	75,136	62,391
Watersmeet	285,742	19,136	55,779	100,270	110,557	242,171	17,958	50,896	87,825	85,492
All districts	1,451,258	140,648	329,456	476,802	504,352	1,262,270	136,679	302,582	403,600	419,409

Table 7.--Net volume of all live trees on timberland by species group and forest type, Ottawa National Forest, 1993

(In thousand cubic feet)

Species group	All types	Jack pine	Red pine	White pine	Balsam fir	White spruce	Black spruce	Northern white-cedar	Tamarack	Oak-hickory	Elm-ash-soft maple	Maple-beech-birch	Aspen	Paper birch	Balsam poplar
Softwoods															
Jack pine	24,269	17,385	1,422	-	-	626	2,118	-	-	-	-	2,302	416	-	-
Red pine	75,090	199	68,571	739	905	386	341	-	-	391	-	690	2,868	-	-
White pine	41,289	-	5,331	13,089	7,660	-	1,464	624	-	382	378	5,808	6,553	-	-
White spruce	58,387	-	2,926	1,717	15,068	7,054	265	1,660	134	-	2,038	18,755	8,273	497	-
Black spruce	25,935	-	1,432	-	2,780	1,594	12,784	2,391	1,744	-	178	1,927	1,105	-	-
Balsam fir	64,238	-	1,989	862	16,716	865	2,228	5,866	175	-	3,577	19,639	9,782	2,463	76
Hemlock	77,658	-	-	-	713	-	-	1,072	-	-	2,974	72,184	561	154	-
Tamarack	15,458	-	709	-	595	237	2,677	2,238	5,196	-	-	2,147	1,436	223	-
Northern white-cedar	86,887	-	-	182	7,270	200	504	41,399	3,378	-	9,734	21,894	2,085	241	-
Other softwoods	893	-	893	-	-	-	-	-	-	-	-	-	-	-	-
Total softwoods	470,104	17,584	83,273	16,589	51,707	10,962	22,381	55,250	10,627	773	18,879	145,346	33,079	3,578	76
Hardwoods															
Select white oak	1,009	-	-	203	-	-	-	-	-	-	-	-	806	-	-
Select red oak	14,737	-	941	885	-	-	-	-	-	4,581	-	7,396	934	-	-
Basswood	68,985	-	-	-	323	-	-	133	-	-	-	68,073	456	-	-
Yellow birch	79,405	-	-	-	2,597	88	326	3,027	-	-	3,180	69,347	551	289	-
Hard maple	395,233	-	1,485	868	2,190	310	-	699	-	-	2,662	382,872	4,020	127	-
Soft maple	165,772	-	530	2,214	7,098	-	143	5,119	-	579	6,240	132,522	10,098	1,229	-
Elm	1,055	-	-	-	-	57	118	-	-	-	-	880	-	-	-
Black ash	36,376	-	-	-	1,886	-	-	1,482	-	-	11,588	19,702	1,594	124	-
White & green ash	11,491	-	-	-	-	-	-	-	-	-	-	9,641	1,850	-	-
Balsam poplar	1,691	-	-	-	-	-	-	-	129	-	-	-	1,562	-	-
Bigtooth aspen	15,725	209	377	-	474	-	-	-	-	1,227	-	3,672	9,766	-	-
Quaking aspen	128,093	2,120	4,239	1,178	10,736	4,220	353	110	89	-	7,096	44,128	52,072	1,752	-
Paper birch	37,689	126	2,470	2,989	2,747	1,116	1,141	1,904	-	215	-	10,555	4,837	9,589	-
Black cherry	21,416	-	-	-	1,637	-	126	-	96	-	270	17,645	1,642	-	-
Other hardwoods	164	-	-	-	53	-	-	-	-	-	-	111	-	-	-
Noncommercial hardwoods	2,313	-	-	-	-	-	-	-	-	-	-	2,186	127	-	-
Total hardwoods	981,154	2,455	10,042	8,337	29,741	5,791	2,207	12,474	314	6,602	31,036	768,730	90,315	13,110	-
All species	1,451,258	20,039	93,315	24,926	81,448	16,753	24,588	67,724	10,941	7,375	49,915	914,076	123,394	16,688	76

Table 8.--Net volume of growing stock on timberland by species group and diameter class, Ottawa National Forest, 1993

(In thousand cubic feet)

Species group	All classes	Diameter class (Inches at breast height)									
		5.0- 6.9	7.0- 8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods											
Jack pine	23,741	1,479	7,632	8,793	2,890	2,539	408	-	-	-	-
Red pine	74,510	7,256	16,616	18,592	15,214	7,433	3,130	3,593	959	1,717	-
White pine	38,428	252	186	1,850	2,384	3,347	3,855	4,376	5,723	13,628	2,827
White spruce	57,914	6,225	8,496	9,203	8,427	9,875	5,962	7,048	1,656	1,022	-
Black spruce	25,663	9,244	8,739	5,716	1,094	298	412	160	-	-	-
Balsam fir	63,433	23,043	19,728	12,354	5,824	2,118	252	-	-	114	-
Hemlock	69,234	641	1,421	4,953	7,682	7,723	9,385	9,867	10,258	16,778	526
Tamarack	15,135	2,540	4,173	3,137	1,934	1,639	795	621	296	-	-
Northern white-cedar	70,310	6,136	9,678	17,840	10,974	11,610	6,501	3,868	1,532	2,171	-
Other softwoods	893	232	-	661	-	-	-	-	-	-	-
Total softwoods	439,261	57,048	76,669	83,099	56,423	46,582	30,700	29,533	20,424	35,430	3,353
Hardwoods											
Select white oak	635	-	-	-	-	635	-	-	-	-	-
Select red oak	12,836	194	1,186	1,519	3,116	1,590	1,483	1,519	1,173	1,056	-
Basswood	64,199	2,944	8,441	10,961	17,184	12,218	5,309	4,324	1,890	928	-
Yellow birch	55,979	5,007	7,264	8,059	6,187	5,677	8,667	6,104	5,040	3,682	292
Hard maple	339,245	46,012	64,485	57,457	36,340	27,687	27,041	27,883	21,335	29,088	1,917
Soft maple	135,251	25,608	29,070	26,836	16,497	14,575	9,954	6,217	3,827	2,667	-
Elm	880	-	-	-	-	-	346	346	-	188	-
Black ash	32,329	5,859	8,884	6,335	4,668	3,902	1,715	387	381	198	-
White & green ash	10,714	1,280	1,194	1,726	1,937	1,172	1,794	829	535	247	-
Balsam poplar	1,691	-	-	470	740	185	-	296	-	-	-
Bigtooth aspen	14,043	676	1,053	1,353	2,247	4,854	1,648	1,157	568	487	-
Quaking aspen	108,423	8,698	13,911	18,830	25,691	16,887	13,466	7,669	2,178	1,093	-
Paper birch	32,626	5,104	10,148	7,859	4,948	3,114	1,345	-	108	-	-
Black cherry	14,158	2,196	3,411	5,002	1,276	1,442	557	-	-	274	-
Total hardwoods	823,009	103,578	149,047	146,407	120,831	93,938	73,325	56,731	37,035	39,908	2,209
All species	1,262,270	160,626	225,716	229,506	177,254	140,520	104,025	86,264	57,459	75,338	5,562

Table 9.--Net volume of sawtimber on timberland by species group and diameter class, Ottawa National Forest, 1993

(In thousand board feet)[1]

Species group	All classes	Diameter class (Inches at breast height) 9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods									
Jack pine	70,571	41,374	14,143	12,867	2,187	-	-	-	-
Red pine	263,399	93,417	78,064	39,286	17,133	20,034	5,450	10,015	-
White pine	204,750	8,442	11,270	16,450	19,747	23,123	31,098	77,709	16,911
White spruce	232,651	46,540	44,057	53,133	33,068	40,098	9,642	6,113	-
Black spruce	40,306	29,544	5,856	1,636	2,331	939	-	-	-
Balsam fir	100,228	58,882	28,553	10,809	1,336	-	-	648	-
Hemlock	356,652	23,658	37,024	38,384	48,676	52,826	56,599	96,270	3,215
Tamarack	43,987	15,570	9,990	8,799	4,405	3,508	1,715	-	-
Northern white-cedar	280,215	88,055	55,334	60,167	34,643	21,088	8,530	12,398	-
Other softwoods	3,099	3,099	-	-	-	-	-	-	-
Total softwoods	1,595,858	408,581	284,291	241,531	163,526	161,616	113,034	203,153	20,126
Hardwoods									
Select white oak	2,739	-	-	2,739	-	-	-	-	-
Select red oak	44,379	-	12,548	6,896	6,759	7,149	5,651	5,376	-
Basswood	187,482	-	72,568	55,016	24,933	20,928	9,295	4,742	-
Yellow birch	172,517	-	26,440	26,359	42,195	30,550	25,774	19,548	1,651
Hard maple	797,888	-	149,409	123,876	126,233	134,282	105,410	148,429	10,249
Soft maple	238,999	-	67,002	64,371	45,842	29,748	18,642	13,394	-
Elm	4,074	-	-	-	1,537	1,633	-	904	-
Black ash	51,233	-	20,185	17,961	8,219	1,905	1,929	1,034	-
White & green ash	29,139	-	7,795	5,247	8,290	3,963	2,607	1,237	-
Balsam poplar	5,347	-	3,108	835	-	1,404	-	-	-
Bigtooth aspen	50,480	-	9,459	22,124	7,868	5,666	2,867	2,496	-
Quaking aspen	303,317	-	108,936	76,795	63,629	37,519	10,850	5,588	-
Paper birch	40,304	-	20,042	13,574	6,156	-	532	-	-
Black cherry	15,637	-	5,224	6,462	2,585	-	-	1,366	-
Total hardwoods	1,943,535	-	502,716	422,255	344,246	274,747	183,557	204,114	11,900
All species	3,539,393	408,581	787,007	663,786	507,772	436,363	296,591	407,267	32,026

[1] International 1/4-inch rule.

Table 10.--Net volume of growing stock and sawtimber on timberland by county and major species group, Ottawa National Forest, 1993

County	Growing stock					Sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	Thousand cubic feet					*Thousand board feet* [1]				
Baraga	48,421	3,980	7,863	17,387	19,191	172,734	16,733	35,950	61,046	59,005
Gogebic	391,355	28,964	117,254	118,769	126,368	1,038,345	121,481	389,842	250,416	276,606
Houghton	234,631	38,298	59,913	68,099	68,321	720,254	142,720	232,824	142,954	201,756
Iron	235,007	33,946	55,128	69,065	76,868	689,441	153,230	178,055	149,166	208,990
Ontonagon	352,856	31,491	62,424	130,280	128,661	918,619	104,556	220,467	293,291	300,305
All counties	1,262,270	136,679	302,582	403,600	419,409	3,539,393	538,720	1,057,138	896,873	1,046,662

[1] International 1/4-inch rule.

Table 11.--Net volume of all live trees and salvable dead trees on timberland by class of timber and major species group, Ottawa National Forest, 1993

(In thousand cubic feet)

Class of timber	All species	Major species group			
		Pine	Other softwoods	Soft hardwoods	Hard hardwoods
Live trees					
Growing-stock trees					
Sawtimber					
Saw-log portion	577,041	91,181	177,239	143,583	165,038
Upper stem portion	152,480	12,077	25,047	56,368	58,988
Total	729,521	103,258	202,286	199,951	224,026
Poletimber	532,749	33,421	100,296	203,649	195,383
All growing-stock trees	1,262,270	136,679	302,582	403,600	419,409
Cull trees					
Short-log trees	43,876	958	9,163	15,260	18,495
Rough trees					
Sawtimber	52,134	2,156	6,903	20,323	22,752
Poletimber	65,505	716	2,749	26,087	35,953
Total	117,639	2,872	9,652	46,410	58,705
Rotten trees					
Sawtimber	23,779	139	7,337	9,677	6,626
Poletimber	3,694	-	722	1,855	1,117
Total	27,473	139	8,059	11,532	7,743
All cull trees	188,988	3,969	26,874	73,202	84,943
All live trees	1,451,258	140,648	329,456	476,802	504,352
Salvable dead trees					
Sawtimber	22,999	1,245	9,623	10,004	2,127
Poletimber	15,073	1,351	3,465	7,904	2,353
All salvable dead trees	38,072	2,596	13,088	17,908	4,480
All classes	1,489,330	143,244	342,544	494,710	508,832

Table 12.--Average net annual growth of growing stock and sawtimber on timberland by county and major species group, Ottawa National Forest, 1980-1992

County	Growing stock					Sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	Thousand cubic feet					*Thousand board feet* [1]				
Baraga	954	263	147	41	503	5,476	983	1,048	897	2,548
Gogebic	8,742	1,180	1,813	2,676	3,073	35,672	5,419	11,597	10,540	8,116
Houghton	5,155	960	1,384	1,596	1,215	23,954	6,186	7,047	6,310	4,411
Iron	4,551	890	1,022	820	1,819	22,562	4,939	5,520	5,082	7,021
Ontonagon	7,674	1,192	965	2,638	2,879	29,362	4,174	5,701	11,281	8,206
All counties	27,076	4,485	5,331	7,771	9,489	117,026	21,701	30,913	34,110	30,302

[1] International 1/4-inch rule.

Table 13.--Average annual removals of growing stock and sawtimber on timberland by county and major species group, Ottawa National Forest, 1980-1992

County	Growing stock					Sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	Thousand cubic feet					*Thousand board feet* [1]				
Baraga	861	115	-	627	119	1,003	435	-	-	568
Gogebic	3,302	545	229	1,504	1,024	10,602	2,193	870	4,716	2,823
Houghton	2,255	360	483	1,352	60	3,344	631	730	1,836	147
Iron	2,850	51	1,449	634	716	8,126	228	2,931	1,525	3,442
Ontonagon	3,813	-	220	2,586	1,007	9,562	-	1,222	6,057	2,283
All counties	13,081	1,071	2,381	6,703	2,926	32,637	3,487	5,753	14,134	9,263

[1] International 1/4-inch rule.

Table 14.--Average net annual growth, average annual mortality, and average annual removals of growing stock and sawtimber on timberland by species group, Ottawa National Forest, 1980-1992

Species group	Growing stock			Sawtimber		
	Average Net Annual Growth	Average Annual Mortality	Average Annual Removals	Average Net Annual Growth	Average Annual Mortality	Average Annual Removals
	Thousand cubic feet			*Thousand board feet* [1]		
Softwoods						
Jack pine	364	277	712	3,349	275	2,040
Red pine	3,014	69	119	12,158	212	375
White pine	1,107	133	240	6,194	368	1,072
White spruce	1,889	398	204	9,788	1,555	1,129
Black spruce	215	597	788	728	867	511
Balsam fir	107	3,023	1,185	1,328	5,655	3,116
Hemlock	889	311	19	6,347	1,592	95
Tamarack	396	62	-	1,800	166	-
Northern white-cedar	1,790	122	185	10,694	642	902
Other softwoods	45	-	-	228	-	-
Total softwoods	9,816	4,992	3,452	52,614	11,332	9,240
Hardwoods						
Select white oak	-26	35	-	-99	152	-
Select red oak	254	64	-	1,602	170	-
Basswood	1,610	150	528	7,753	494	1,395
Yellow birch	260	872	334	2,604	2,707	1,312
Hard maple	8,670	876	2,560	25,266	2,013	7,801
Soft maple	3,697	343	580	8,791	561	535
Elm	-1,481	1,593	274	-3,247	3,623	1,011
White & green ash	630	166	12	1,359	176	56
Black ash	331	41	32	929	138	150
Balsam poplar	63	4	103	251	18	261
Bigtooth aspen	495	78	599	2,837	118	350
Quaking aspen	2,140	2,424	4,372	13,542	5,321	10,246
Paper birch	411	426	174	1,237	577	-
Black cherry	206	133	61	1,587	100	280
Total hardwoods	17,260	7,205	9,629	64,412	16,168	23,397
All species	27,076	12,197	13,081	117,026	27,500	32,637

[1] International 1/4-inch rule.

Table 15.--Volume of sawtimber on timberland by species group and butt log grade or tree grade, Ottawa National Forest, 1993

(In thousand board feet)[1]

Species group	All grades	Butt log grade 1	2	3	4
Softwoods					
Jack pine	70,571	-	2,346	68,225	-
Red pine	263,399	63,369	15,335	184,695	-
White pine	204,750	19,548	57,581	123,067	4,554
White spruce	232,651	-	7,242	225,409	-
Black spruce	40,306	-	-	40,306	-
Balsam fir	100,228	-	-	100,228	-
Hemlock	356,652	4,423	38,941	313,288	-
Tamarack	43,987	-	3,146	40,841	-
Northern white-cedar	280,215	-	4,424	275,791	-
Other softwoods	3,099	-	49	3,050	-
Total softwoods	1,595,858	87,339	129,063	1,374,902	4,554

	All grades	Tree grade 1	2	3	Tie and timber
Hardwoods					
Select white oak	2,739	-	-	2,739	-
Select red oak	44,379	8,663	6,151	23,206	6,358
Basswood	187,482	21,132	50,717	106,616	9,018
Yellow birch	172,517	27,343	34,796	98,559	11,819
Hard maple	797,888	162,277	216,431	351,456	67,723
Soft maple	238,999	17,106	47,325	150,260	24,307
Elm	4,074	292	807	2,561	414
Black ash	51,233	6,573	18,043	24,801	1,815
White & green ash	29,139	7,939	11,969	9,230	-
Balsam poplar	5,347	1,457	2,196	1,694	-
Bigtooth aspen	50,480	-	-	50,480	-
Quaking aspen	303,317	14,778	47,855	225,981	14,703
Paper birch	40,304	4,978	7,052	26,966	1,308
Black cherry	15,637	-	7,167	5,481	2,989
Total hardwoods	1,943,535	272,538	450,512	1,080,031	140,455
All species	3,539,393	359,876	579,575	2,454,933	145,009

[1] International 1/4-inch rule.

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Leatherberry, Earl C; Meunier, James L.
1997. **The forest resources of the Ottawa National Forest, 1993.** Resour. Bull. NC-185. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 41 p.

The inventory of forest resources of the Ottawa National Forest reports 967.0 thousand acres of land, of which 908.6 thousand acres are forested. This bulletin presents an analysis of forest resources focusing on change in tree species composition, timber volume, growth, removals, and mortality.

KEY WORDS: Forest area, timber volume, growth, removals, mortality.

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.